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Abbreviations

LGB: Local Government Board
MOH: Medical Officer of Health
MOsH: Medical Officers of Health

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Acknowledgements

First and foremost, I would like to thank my supervisor, Prof. Simon Szreter, for his help and support over the years. His enthusiasm and knowledge have helped me in numerous ways and saved me from many oversights and omissions. I would also like to thank Graham Mooney for his wise and generous advice on the subject of the thesis, and his help in developing the project. I would also like to thank Tom Crook and Sian Pooley for their advice on aspects of the topic. I am also grateful to the staff and students of the History Faculty for providing such an interesting and wide ranging scholarly culture, has helped enrich my research and my experience as a graduate student.

I am very grateful for the support of the ESRC for funding my MPhil and my PhD, and for the additional funding and support they provide for skills training, conferences and internships: without their help the project would have been impossible. I would also like to thank Trinity College, and Dr. Richard Serjeantson in particular, for their practical support throughout my time at Cambridge. The graduate community at Trinity is vibrant and friendly and it has been a pleasure to live and work with such talented and interesting people.

This thesis has taken me to many archives across the country. I would like to thank the staff at Wellcome Trust Library, Bolton Archive, St. Helens Archive, Sheffield Archive, Liverpool Archive, The Harris Library, The British Library and Lancashire Record Office for their advice and assistance in locating and understanding local sources. Their eagerness to help me get access to uncatalogued, uncleaned, misplaced and obscure documents was impressive, and has greatly added to the development of the project. The staff at the Rare Books Room of the Cambridge

University Library also deserve many thanks for their advice about nineteenth century publications and their patience in fetching hundreds of volumes from the tower.

Finally, I would like to express my gratitude for the help, support and encouragement of my parents and my sister. In particular, I would like to thank my parents for their unwavering support whilst I was undertaking the archive work for this project, and their stellar efforts in proofreading drafts. Their support has been invaluable. I would also like to dedicate this thesis to the memory of my grandmother, Mary Hutchings, who would have been very proud to see the finished work.

Introduction

The nineteenth century has been regarded as the age in which modern approaches to health, public medicine and social policy measures were developed. The mechanisms underpinning disease causation were increasingly understood, public health policy was developed and mortality declined; this was an age of revolution and “scientific progress” where uncertainty gave way to knowledge. For those writing towards the end of this epoch the consequences were clear. People owed their health, even their lives, to the pioneering work of those doctors, scientists and public health professionals who, against apathy, ignorance and hostility, had pushed forward the role of the state in health and set up systems that provided clean water, sewerage, hospitals and health advice.¹ Although this triumphalist vision of the development of public health has been significantly modified by more recent historiographical work, the basic story of the importance of nineteenth century public health in tackling many of the most egregious failings of industrial society and reducing mortality retains prominence in recent work.² Authors such as Wohl, Szreter and Woods have stressed the role of health policies in reducing mortality from infectious diseases.³ Social interventions ranged from capital intensive building projects such as reservoirs and sewage systems, to surveillance of births and disease cases, and health advice that aimed to change infant care and hygiene practices within the home.⁴ These had differing patterns of effectiveness, demonstrating the complexity of the relationship between environment, behaviour and health.⁵ There are, however, some areas of policy which have not been investigated and for which there is a need for more detailed historical analysis. One key area is disinfection: this thesis provides a detailed account of disinfection policies and their significance in nineteenth century public health.

Disinfection and history

Disinfection is a familiar concept in modern life. Advertising slogans for popular disinfectants appeal to profound cultural fears about contamination, promising that their preparations can kill “99.9% of bacteria” and prevent the spread of dangerous germs that lurk in every location.⁶ But where did this concept originate? Did disinfection take shape alongside the germ theory that now legitimizes disinfectant use? How did this change over time? There is no existing detailed literature examining the rise of disinfection, and many of the ways in which the policy developed have been obscure. This is problematic given the apparent role of disinfection as an important everyday public health intervention and an integral part of disease prevention efforts, as we shall see.

The existing literature points to the importance of disinfection as an everyday health intervention at local and national level. In many books, including those by Hardy, Wohl and in particular Baldwin, frequent references are made to the use of “disinfection” policies by the authorities in relation to a range of diseases and circumstances: for instance, Baldwin points to disinfection as a key policy used across Europe in relation to cholera.⁷ He also implicates disinfection in the development of what he terms a “neo-quarantinist” system of disease control.⁸ This approach relied on a network of policies and systems in order to be effective, utilising notification of infectious disease to gather information; isolation hospitals and inspection of isolation facilities at home to ensure separation of the sick and the healthy; and disinfection by heat, steam and chemicals to cleanse personal possessions.⁹ There is also evidence of disinfection’s importance at the domestic level. Hardy points to disinfection as the main policy used to counteract lingering infection in the home and the hospital in relation to childhood infectious diseases.¹⁰ Widespread disinfection policies were clearly pursued in the nineteenth century, but have received little detailed exploration. The development of disinfection needs investigating and placing in context.

The limited attention given so far to the history of disinfection means that there are many aspects of policies of disinfection which require clarification. These include the exact trajectory of developments in techniques of disinfection and their underlying rationale: whether fumigation, chemicals, washing or heat and steam methods were considered effective. There has also been no consideration so far of the changing patterns of disinfection practice at local level over time, space and class. Finally, there is the range of issues surrounding the public reaction to disinfection which remain largely unexplored. This thesis sets out to investigate these issues and disinfection more generally using specific questions. How did definitions of disinfection change over time,

particularly after the advent of germ theory? What consequences did this have for ideas about the effectiveness of disinfectants? Did this result in change in the advice that was given on disinfection? How did these trends play out in practice, and how were they reflected in local public health activities? What problems were encountered when translating from theory to practice? These questions are used to structure the thesis and shed light on the history of disinfection more generally.

Understanding the intellectual and scientific context in which disinfection policies were pursued is important. In many ways, disinfection seems the obvious policy to be pursued in relation to disease in this period: the desire to make things clean and the wariness of potentially disease-ridden items seems nothing but common sense. The extent to which such ideas can be regarded as “obvious” in the context of Victorian knowledge about disease causation is nevertheless a complicated issue, and one which requires careful consideration. The rise of large and insanitary towns in the early nineteenth century created new issues of cleanliness.¹¹ However, despite the apparent historical and historiographical ubiquity of reference to disinfection, the methods of and rationale behind these policies have rarely been explored in detail.

Disease Causation, Chemistry and Science

It is important to understand the historical context of disinfection more generally. This section therefore sets the backdrop for disinfection in terms of developments in disease theory, public health and science in the wider context.

Ideas and theories of disease causation have been explored in detail. A key concept is the issue of “infection” and the link between concepts of “infection”. Theories of disease causation developed in various directions during the nineteenth century, from ideas about decomposition and “zymotic” diseases to the development of germ theory and bacteriological analysis from the 1870s onwards.¹² There is an extensive literature documenting the development of nineteenth-century concepts of “infection” and “contagion”.¹³ It has been pointed out that the group of reformers associated with Edwin Chadwick favoured an explanation of disease which focussed on the importance of atmospheric ‘miasmas’ and environmental causes as the means of disease transmission.¹⁴ This theory, which became dominant throughout the mid-century, lingered in some form even after the advent of germ theory. There is local evidence, for instance, that the problem of “sewer gas” was still being referred to as a cause of disease as late as the 1890s.¹⁵ Miasmatic theory implied the need for fumigation and deodorization as much as any idea of disinfection.

As many authors have pointed out additional theories of disease emerged in the mid-nineteenth century which drew on and revitalized older ideas of contagion which had been articulated in the eighteenth century.¹⁶ Contagion theory posited that an unknown agent contaminated various materials including the air, but also objects, and thus passed on disease. This theory became dominant over that of miasmas by the late 1860s, preceding the advent of germ theory. Within contagionist theory, disinfection had to deal with purifying a range of materials and possible sources of contamination. Hardy (née. Wilkinson) has also pointed to the increasing categorisation of disease into groups such as “zymotic”.¹⁷ This idea, which drew heavily on the theories of the German organic chemist Justus Von Liebig, claimed that diseases were caused by the effects of fermentation of organic matters, and that particular diseases were thus caused by the distinct stages of decomposition and by the differential decomposition of different materials.¹⁸ It blended easily with the idea of contagion. In terms of disinfection, this theory advocated the arrest of fermentation and decomposition as the key to stopping the progress of disease. There were, therefore, several theories of disease causation which were developing in the nineteenth century and, as Baldwin has shown, they were all capable, for different reasons, of producing a recommendation to adopt practical disinfection. The differences between them do, however, offer fruitful grounds for investigation.

The advent of germ theory in the period from 1870 onwards changed the understanding of disease causation. Worboys’ impressive work on germ theory makes an admirable and vital contribution to the literature on public health and disinfection.¹⁹ Worboys points to the “seed and soil” metaphor as an extremely influential model of germ theory, which cut across many areas of medicine, surgery and public health.²⁰ He points to the more diffuse and nebulous impacts of germ theory on public health, but also that germ theory was used in a variety of ways to shape both “inclusive” and “exclusive” public health interventions, especially the narrowing of aims which occurred in the 1880s.²¹ In the particular case of disinfection, this meant a narrowing of the focus away from issues of wider environmental cleansing, and re-orientation towards a specific emphasis on killing “germs”. Nevertheless, as Mooney has pointed out, there was also a focus on people as well as infected places, with the move towards policies of notification of infectious disease, and the isolation of patients.²² This narrowing of policy at a national level was probably reflected in the remaking of disinfection ideas at local level which could have been quite diverse: disinfection could be fitted into a range of public health interventions and models of

disease causation. The intricacies of this have not been fully documented, and provide a framework for the wider implications and importance of comparative local study. The exact practices and conceptual underpinnings of disinfection are thus important and relatively unexplored at both national and local level. As discussed earlier, the concept of infection is relevant to understanding how disinfection was directed, and discontinuities and discrepancies in this over time and space are especially important.

Developments in the theory and practice of other sciences were also relevant to disinfection, which relied heavily on chemical preparations and physical processes. The history of chemistry and physics is, therefore, an important backdrop to the implementation of new methods. It is not the purpose of this thesis to engage with the detailed theoretical and intellectual developments in the history of chemistry in detail. It is, however, necessary to sketch out the broad developments.

The nineteenth century saw significant developments in theoretical chemistry. These occurred across various nations and built on foundations established in the eighteenth century.²³ Atomic theory was developed by a number of researchers and is most associated with John Dalton who was working in the first half of the century.²⁴ Berzelius then demonstrated that the theory could be universally applied, and Avogadro enhanced this with his hypothesis on the relationship between volume and number of molecules of gases.²⁵ Chemists throughout the nineteenth century “had difficulties with atoms and their ontological variance” as well as with their characteristics, as they attempted to construct theoretical tools that would allow deeper investigation of experimental results.²⁶ There were also advances in the understanding of the classification of the elements and compounds, culminating in Mendeleyev’s famous conclusions and predictions about periodicity in 1869.²⁷ Particular specialisms also developed. Understanding of electrochemistry was advanced by workers like Volta, Sir Humphry Davy and Michael Faraday, and led to practical discoveries and the advancement of the investigation of molecular architecture.²⁸ Organic chemistry, the study of compounds of carbon, also increasingly came to prominence from the middle of the century, developed by Justus von Liebig and others.²⁹ This was developed by other researchers, including Kekule, who established the structure of benzene.³⁰ Finally, physical chemistry, which blended chemistry and physics, also grew in importance, examining puzzles such as the structure of the atom and the implications of radioactivity for

chemistry.³¹ As previously mentioned, these developments in chemistry and other sciences were also allied to thinking about disease, as in the case of Liebig's theories.³² Besides theoretical developments, chemists also discovered numerous new elements and compounds throughout the century.³³ The theory of chemistry and the extent of chemical knowledge thus grew greatly in the nineteenth century, transforming the subject and laying the foundations of modern chemistry.³⁴

Practical chemistry was also transformed and new industrial applications of chemical processes proliferated. The chemical industry grew spectacularly between 1850 and 1870, producing both heavy and fine chemicals.³⁵ Many new chemicals were identified, synthesised and developed, with this process speeding up towards the end of the century.³⁶ Production was also stimulated by the greater range of chemicals required for industry.³⁷ In particular, the textile industry needed bleaches, dyes and other chemicals.³⁸ Medical and health applications of these new chemicals also widened.³⁹ In this way, the nineteenth century saw an increasing range of chemicals put to new uses, including disinfection.

Public Health at Local and National Level

As well as understanding the scientific rationale behind disinfection we must consider the wider application and administration behind the local public health policies that were related to it. As mentioned earlier, a much wider range of works discussed the national attempts from the 1830s onwards to improve the quality of local public health, in particular the Chadwickian attempts to clean up the environment. Historians have explored the development of public health from initial problems and failings, through increasing local efforts in the 1850s and 1860s, to a resurgence of national interest in the 1870s.⁴⁰ Public health remained a contested policy which provoked significant debate, but its role in politics and society became increasingly more important and far reaching. This was accompanied by an increase in the intensity and range of public health policies pursued. From the 1870s to the 1890s there was a dramatic increase in the range of legal powers available to local authorities, and the public health activities they undertook.⁴¹ The intensification of public health policy in the period from 1870 onwards provides a backdrop to changes in disinfection policy and indicates that there was a haphazard increase in attention to health. This provides a background to understanding disinfection policies.

The focus of the public health movement has also gained attention. Historians have broadly agreed that there was a move from an environmental focus to a person-centric-approach

to disinfection after the 1880s, also expressed as a shift in “inclusive” versus “exclusive” policies.

⁴² This was manifested in a relative decline in focus on policies like nuisance management, clearing up filth, and other activities aimed at reducing generalised dirt, and an increase in policies which focussed on the infected person as the vector of transmission, such as notification, isolation, personal cleansing and contact tracing. The change in approach has been broadly associated with the development of germ theory. As research revealed that germs did not spontaneously appear, and that there were “hidden carriers” in diseases like typhoid, it increasingly seemed that diseases could be eradicated only if strict attention was paid to controlling the movement and behaviour of infected persons. This thesis provides evidence that in practice disinfection did not necessarily follow this trend, and indicates that we should reassess this hypothesis.

Particular sets of policies also provide important contexts when considering disinfection, especially the role of inspectors of nuisances, clearing of nuisances and other such interventions which dealt broadly with allied ideas of cleanliness and hygiene. It was within these structures that the policies of disinfection were frequently provided and administered. In many cases, local authorities used the same departments and personnel to administer disinfection and nuisance inspection; and so the everyday nature of disinfection policies would often reflect the influence of earlier and established practices of administration of nuisances. The management of nuisances is therefore a key area for understanding the management of disinfection policies at local level.

The literature on this area is relatively well developed, with authors including Kearns, Hamlin and Crook making important contributions to our understanding of nuisance inspection.⁴³ Much of this local work rested on such basic and legalistic concepts as nuisance reporting and clearance and although these are referenced in many works, including those by Wohl, relatively few detailed examinations of these issues have been made.⁴⁴ Recent scholarship has examined the concept of nuisances and nuisance removal, covering a range of relevant aspects. The first one was a legal obligation on local authorities to manage nuisances. Broad policies of nuisance removal were important in relation to the day-to-day running of public health at local level, as both Wilkinson and Kearns have pointed out.⁴⁵ Kearns’ work on nuisance removal in Islington indicated the key importance of “normal” sanitary work such as clearing the roads of filth, dealing with complaints and other routine measures in the overall programme of work of the local sanitary authorities.⁴⁶ This work intensified in the face of cholera epidemics, demonstrating that much of the response to such crises was not wide-ranging new measures, but more assiduous

application of the usual policies.⁴⁷ Hamlin claims that we know relatively little about the day-to-day policing of sanitary matters, including nuisances, and this could also apply to other day-to-day concerns including disinfection, reinforcing the importance of the research for this thesis.⁴⁸

Besides a consideration of the application of policy over time, there are wider concerns in relation to nuisance removal, within which certain aspects of disinfection policy operated. The influencing factors behind what was considered to be a nuisance are clearly important in understanding the concept of local sanitary policing and provide an interesting parallel to disinfection. The issue of how nuisances were identified and reported also raises parallels with policies of disinfection. Nuisances could be brought to the attention of the local authorities in a number of ways. Before 1866, this was done chiefly via complaints from the public at large, which were then investigated.⁴⁹ Under the 1866 Sanitary Act, authorities were compelled to appoint inspectors of nuisances, and the powers of these inspectors were also considerably extended to allow them actively to seek out nuisances.⁵⁰ Wilkinson has, however, highlighted the problems of day-to-day management of nuisances under the 1866 Act, claiming the remit of the law was not clear, that parts of it could clash with other parts, and that it could be difficult to work within the terms of the law: for instance, determining who was the legally-defined landlord could be problematic for extensively sub-let slum properties.⁵¹ Later legislation including local acts and bye-laws concerning housing and also the Notification of Infectious Disease Acts, extended the structure of surveillance and the ways in which problems could come to light, and thus added to the management of nuisances. This raises clear parallels with the ways in which property and houses came to be subject to policies of disinfection. Disinfection was often incorporated within nuisance inspection from the 1860s onwards. Houses and belongings were most often disinfected when a case of infectious disease had occurred within the household. This information could reach the sanitary authorities in various ways: it could be provided by the inhabitants themselves, by other informants such as neighbours or medical professionals, by the investigations of sanitary staff. However, only after the passing of laws for compulsory notification of infectious disease did this become a compulsory process, have to be notified to the authority by medical professionals or householders. These various sources of information could all lead to visits from inspectors, and attempts to rectify the defect. Disinfection utilised similar methods of information gathering as nuisances and followed a similar pathway from voluntary to compulsory later in the century.

The actual day-to-day work of policing nuisances also has relevance to the issue of locally-devolved state disinfection policy. Local authorities were compelled to appoint specific

nuisance officers under the 1866 Sanitary Act, and these workers frequently formed the “front line” in the sanitary fight.⁵² Disinfection was often subsumed within the duties of these officers, and even when specific disinfection officers were appointed, their work structures had significant commonality with nuisance officers. In considering the role of nuisance inspectors in different areas across the country, Hamlin has pointed out patterns in nuisance reporting and removal.⁵³ Policy clearly varied between areas, and the role of the nuisance inspector could or could not be well-defined depending on many factors, such as wealth, job security and tenure and the size of town. This diversity of experience highlights that day-to-day public health interventions varied according to the characteristics of local areas; this is explored in relation to disinfection later in the thesis.

There is an existing literature on the development of professional identities in the nineteenth century. The second half of the nineteenth century saw a series of important developments that increasingly located certain kinds of knowledge and expertise within the remit of particular groups of professionals and experts. The medical profession battled to delineate the boundaries of their profession, excluding “quacks” and “charlatans” from acceptable practice, and increasing their own status in society.⁵⁴ Whilst not achieving all their aims, by 1914 the medical profession was significantly more unified and higher in status, than in 1850. Other professions including chemists were also carving out their own identities and areas of expertise.⁵⁵ These professional boundaries could bring them into conflict with each other and with other authorities over who had the right to use specialist knowledge and advise on policy.⁵⁶ The role of the expert in local and national government policy has also been examined. MacLeod has shown the increasing role of experts and the concept of expertise in advising government in developing policies in a number of areas; this was not always straightforward. The institutionalisation of the expert was neither simple nor uniform, and the role of expert opinion varied over time. In particular, there were both “practical” experts who had knowledge based in experience, and scientists who aimed to extend and promote scientific knowledge.⁵⁷ These developments hold particular significance for disinfection and this distinction will be a major theme to be explored in subsequent chapters. The exact nature of expert advice could also be troubling. Hamlin has shown that whilst local authorities wanted to use “expert” advice to help shape policies in water provision, for instance, it was often difficult to ascertain where expertise and reliable advice lay as there were significant differences in expert advice.⁵⁸ This meant that local authorities often

operated in a climate of confusion, unable to choose which path was the correct one, and thus putting off action to avoid problems.⁵⁹ This highlights the ways in which scientific knowledge was of increasing importance in informing the development of policy, but also how this could be a contested and troublesome process.

The Public and Public Health

Public reactions to public health policies, such as disinfection, are exceedingly important in understanding their impact and possible success.⁶⁰ For instance Durbach has shown how policies of compulsory smallpox vaccination implemented in the second half of the nineteenth century provoked significant opposition from many sections of the population, including both working class and middle class groups.⁶¹ Smallpox vaccination officers saw vaccination in terms of preventing smallpox epidemics by ensuring that all the population was protected, and thus those who refused to have their children vaccinated were recklessly endangering not only their lives, but also the rest of the population. From the perspective of those opposing vaccination, however, the state-sanctioned introduction of “unclean” lymph into the bodies of their children was a violation, and one which should not be allowed under English law. The views of the officers and the public were incompatible. Understanding public reactions to public health policies in this period must take account of the different set of priorities which the public might harbour, which were not in line with the straightforward “disease prevention” agenda of the authorities. Graham Mooney’s work on the public reaction to policies of compulsory notification of infectious disease also raises some interesting questions and parallels concerning public reactions to intrusive policies.⁶²

Besides the specifics of reaction to particular policies, it is also important to understand the ways in which public health policy and health in general were regarded in this period by the population at large. Beier has undertaken some work examining popular working class attitudes to issues of health and policy, looking in particular at three urban areas within North Lancashire.⁶³ Her work raised questions about how the public interacted with health authorities, and how working class women in particular understood the policies they were expected to comply with. Beier claims that working-class health culture largely valued low-cost self-help remedies, and also that adult women were usually the ones in charge of matters of disease prevention, diagnosis and control.⁶⁴ This is clearly of relevance when considering the impact of disinfection policies within the household. However, class and gender differences between inspectors and the women whose houses they were inspecting are clearly of importance in these interactions. In the case of

disinfection, the reactions of household residents to the issues are important, as many of the techniques required a good degree of input and work in order to make them successful. The role of women as active participants in health is relevant to this. Ideas about health culture are therefore important in understanding public reactions to disinfection, but also for gauging the potential effectiveness of such policies.

As well as the impact of health policy in general, the reception, shaping and understanding of policies, particularly relating to germ control within the middle class and working class home, are important. Tomes' work on late nineteenth century American popular attitudes to germ theory highlights some issues in the way germs were conceptualised by the public, and these also have relevance to the British case.⁶⁵ She points to the role of popular views of germs and education to enhance this understanding as important in developing the perception that extreme cleanliness, and a dogged commitment to cleaning was essential to ensure the health of the family.⁶⁶ She also points to particular campaigns, such as those against spitting, as important in changing ideas about health practice and behaviour.⁶⁷ These considerations, although not perhaps directly relevant to the issues at hand for the British case, raise some compelling questions about the public basis of disinfection policy in Britain. Kelley's recent work on cultures of cleanliness and housework touches on the importance of germs in the British context, and identified many of the same themes as Tomes. Kelley found that germs were increasingly linked to dirt and dust in the public consciousness, making cleanliness part of disease prevention.⁶⁸ The ways in which the public received information about the emerging ideas of germ theory, and how far the authorities' policies on disinfection intersected with popular ideas about similar topics are extremely important in understanding the impact and effectiveness of disinfection policies in this period.

More theoretical ideas of cleanliness and hygiene are also crucial in understanding disinfection policy and the reactions to it. A detailed body of literature, both within and outside the field of history, examines general ideas of cleanliness in society, and also how "dirt" is defined and categorized. One key work in this field is *Purity and Danger* by Mary Douglas. The main argument is that concepts of dirt can be traced back to the idea that dirt is essentially disorder, and that it is "a matter out of place".⁶⁹ More recent works have criticised this approach, but it remains an interesting place to start considering what exactly is meant by dirt, and its bearing on various policies.⁷⁰ Other works have examined the social importance of ideas of cleanliness. Smith has also examined the history of social status and purity, pointing to the frequently occurring

importance of cleanliness as a marker for social status, including everything from ritual cleanliness associated with religion, to the simple but changing social consensus on levels of personal cleanliness.⁷¹ This idea has also been explored in relation to France by Vigarello, who highlights the importance of changing standards of personal hygiene over the *long durée*.⁷² One crucial development was of “markers” of cleanliness which designated social status: for instance, the wearing of white collars and cuffs which rapidly became dirty and thus had to be cleaned or changed frequently. However, he also argues that this did not necessarily filter down the social scale until much later, pointing to large disparities in acceptable personal hygiene. Finally, work on nineteenth and twentieth century working-class culture has pointed to particular examples of these tendencies in this period: for example, whitening the front step of the house to demonstrate that it was clean. Although these patterns do not necessarily have direct bearing on disinfection, they do highlight important aspects of wider cultures of health and cleanliness which would have affected behaviour in relation to disinfection.

As well as issues of content, the literature also provides some interesting methodological approaches which are relevant to this thesis. In particular, Crook’s approach to the work of sanitary inspectors is of interest.⁷³ Rather than taking a broad view of the differences in inspectors’ roles, he looks at the underlying rationales behind the general work of nuisance inspectors. He points out that rather than approaching inspection from either an interventionalist or Foucauldian position, it can be best conceptualised within a framework of liberal governance. The ways in which nuisance officers interacted with local government personnel, science, the central government and most crucially of all, the public, can thus be incorporated into an understanding of how their work was undertaken. The process of inspecting homes and recommending improvements and changes was thus a process of interaction rather than of straightforward imposition. This approach has been underlined by the work of Bartrip concerning factory and mines inspection. Bartrip points to the difference between the “law in books” and the “law in action”, claiming the real workings out of the law were undertaken by the Inspectors themselves.⁷⁴ This is clearly of relevance in relation to appreciating how policies were understood, received and obeyed by the public, but also how the policies themselves were developed and negotiated by staff. Disinfection could be an arduous, messy and potentially destructive policy that invaded the homes of the recipients, but was also a day-to-day practical task undertaken by trained and untrained staff. There was therefore ample scope for negotiation and interaction in these policies.

As we have seen, the existing literature covers a number of areas which are important in setting the scene for the developments in disinfection outlined in this thesis. The claims and insights put forward by the historiography are examined in relation to disinfection later in the thesis, giving a more detailed assessment of their relationship to disinfection policies and how disinfection variously supports and undermines the existing historiography.

Methodology and sources

A full range of sources were used to build up a picture of the development of disinfection in the nineteenth century. These can be split into several main groups. One group of materials that was utilized is published public health and medical texts, both books and journals, and Government reports, parliamentary papers and legislation. These were used to explore disinfection theory, advice and the consequences of disinfection. Secondly, lay publications such as *The Times* were also used to gauge informed public opinion and reactions to disinfection. Local sources, including medical officer of health reports, local council minutes, local press, and miscellaneous documents from five local case studies were also investigated to examine other responses than those of the national press. A range of other sources was also used, including company records, journals and reports and circulars. These allowed a multi-faceted understanding to be built up of disinfection as an evolving commercial and public activity.

The methodology used is also important. It is helpful to set out the means by which two specific aspects of source analysis were pursued. A key body of information comes from texts on disinfection, health, medicine and disease prevention published throughout the nineteenth century. Several specific monographs and pamphlets on disinfection were published from the 1860s onwards. These were identified by catalogue searches in several copyright libraries, as well as more generalised internet searches and use of bibliographical data from other works. This meant that the majority of specialist disinfection works published in Britain at the time was investigated. A wider series of health texts was also surveyed. Many textbooks and more general works included information about disinfection; this ranged from a specific chapter through smaller sections to offhand references. Keywords such as “public health”, “hygiene”, and “domestic medicine” were used to search online catalogues and databases to identify texts of interest. Several of these did not contain specific information about disinfection; this omission was also recorded and used. Additional works relating to wider public health developments, specific works which were likely to include information pertaining to disinfection, and texts on particular issues such as the sale of poisons were also referred to where appropriate. Whilst not exhaustive, the wide range of works used allows a detailed and informed survey of the

disinfection landscape over time, and provides the backbone of the thesis.

Medical and public health journals were also employed as an additional source of information. Three of these were free text searchable online; these were *The Lancet*, *The British Medical Journal* and *Public Health*. The full run of these journals was searched for specific keywords, namely “disinfectant”, “disinfect”, “disinfecting”, and “disinfection”. Other search terms, including “fumigation” were also used to supplement this information. This identified the great majority of relevant articles. Many of these were part of a wider series, where a particular column appeared in every issue; for example, the “Medical News” column of *The Lancet*. These usually blended factual information and opinions which were evidently approved of by the journal’s editorial board, although not attributed to them. Where these are referenced they are attributed to anonymous authors, but can be assumed to accord reasonably well with the views of the journal editor. Journals which were available only in paper format were scanned by looking in the index for the same terms as were used in internet searches. The various medical and public health texts are crucial to the thesis, and the methodology used to identify articles of interest was able to capture a wide range of texts about disinfection.

The use of case studies was also grounded in, and informed by, the existing historiographical use of case studies. Using several examples as the basis for examination of policies at local level is a well established way to approach the history of public health, and has been used by several historians.⁷⁵ The method allows for detailed understanding of the factors affecting policy development at local level and the particular interactions between them as well as for placing specific local practices in the broader context. This thesis uses five case studies of Lancashire towns, namely Manchester, Liverpool, St. Helens, Bolton and Preston, to examine the development of disinfection policy at a local level, the comparison of characteristics and the probability of knowledge transfer. A range of documents and secondary texts relating to each area was investigated in order to ascertain the characteristics and nature of local policy. This was in line with the use of case studies in other works. The case studies were chosen for the availability of sources and the local characteristics so as to provide variety in the areas selected. These specific examples were then supplemented with information about policy in the county as a whole derived from county council medical officer of health reports set against the background of national policy. The other sources consulted indicate that, whilst each of these five local authorities had its own trajectory, the areas studied are representative of the country as a whole and can be used as a basis for understanding the operation of local policy.

Structure of the thesis

As we have seen, the general literature on disinfection and related topics is wide ranging, but does not elucidate the central issue of changing aspects of disinfection theory, and how, when and why disinfection policies were pursued in particular ways at local and national level. This thesis aims to shed light on this matter by drawing on the general material and linking it with detailed study of a range of primary documents concerning disinfection as a public health intervention. This is not an exhaustive summary of all facets of disinfection activities in the nineteenth century; the discussions concentrate on the central issue of how an everyday health concept was approached, practiced and employed.

It is important to understand what was meant by the term “disinfection”, what was excluded from it, and how this changed over time. Chapter Two takes contemporary and historiographical discussions and assumptions about the role of disinfection and looks at how definitions of disinfection were affected by changing ideas about disease causation and the advent of germ theory. Using a variety of books, medical and public health journals and newspapers, this chapter explores the new limits and boundaries of what was seen as disinfection, and highlights the increasingly exclusive equation of “germicide” with “disinfection”.

With the definition of disinfection changing over time the methods advised for different purposes demand examination. Chapter Three therefore turns to the methods and chemicals which were recommended for practical disinfection. Using medical texts, journals, public health publications and advice books aimed at the popular market this chapter charts what advice was given, and how these recommendations changed over time and varied between types of publications. It shows that despite changes in the definition of disinfection, germ theory had only ambivalent effects on disinfectant advice. Whilst some areas of advice changed, others remained largely unaffected by new theories.

Similar trends were also evident in disinfection practice. The main way in which disinfection was delivered was through the activities of local public health authorities. The implementation of disinfection policy in five case study areas of different size, occupational make-up and politics, is then investigated in Chapter Four. The progress of policy, its reception and the factors constraining it are explored in detail, and compared and contrasted across the case studies. The discontinuities between theory, advice and practice are highlighted even more sharply by the evidence from local areas. Whilst efficacy and the need to kill germs was recognised, considerations of practical implementation were the most important factors shaping disinfection.

The public response to disinfection was a crucial aspect of such practicalities. Chapter Five examines the response of the public to disinfection generally, and how the public themselves

were viewed and taken account of by those directing professional disinfection. On the one hand, while the public were willing to accept some forms of disinfection in certain contexts, it had an ambivalent relationship with municipal disinfection. On the other hand, the professions were deeply distrustful of the ability of the public to undertake disinfection for themselves, and actively tried to promote municipal disinfection as an alternative. This set up significant tensions over the boundaries of disinfection, and who should undertake it.

These tensions were perpetuated in other debates. Chapter Six looks at how the issue of safety was approached in relation to disinfection, and the problems and policies it provoked. The problem of accidental poisoning and suicide caused by disinfectant chemicals highlighted the tensions in balancing the various properties a disinfectant needed to have, and the general unwillingness of the government to consider regulation of disinfectants. These issues are pursued further in Chapter Seven, which examines the ways in which disinfectants were tested, and how their effectiveness was judged both before and after the advent of germ theory. This highlights that disinfectant effectiveness was a concern throughout the century. Germ theory added a new location, namely the laboratory, where assessment of disinfectants could take place, and offered the promise of a “scientific” end to debates about which methods were effective. This did not, however, necessarily translate simply and directly into practice, leaving disinfection research increasingly divorced from the realities on the ground facing MOsH.

Chapter Two: Defining Disinfection in the Era of Germ Theory

Defining what was meant by disinfection is essential to understanding its role. Disease theories changed rapidly during the nineteenth century, increasingly converging on the notion that germs, in particular bacteria, caused infectious disease. Disinfection too underwent significant changes, with definitions developing in accordance with changing disease theories. This chapter traces the development of ideas about disinfection up to 1914, and examines the impact of new medical and scientific theories and knowledge on disinfection theory at national level. Definitions of disinfection from a variety of specialist, professional medical and popular advice texts published in the second half of the nineteenth century are explored in order to illustrate the changing complexity of ideas about disinfection. These texts show that germ theory had a significant impact on disinfection definitions and ideas, so that by 1914 disinfection was almost exclusively defined as germicide. Nevertheless, this development was not as

uncomplicated or straightforward as contemporary commentators thought.

Setting the Scene: Disinfection 1800-1866

The importance and legitimacy of disinfection before germ theory has been questioned by several authors. Commentators in the later nineteenth century often thought that increased attention on disinfection occurred post-1880; this viewpoint also appears in some of the historiography.⁷⁶ Whilst there is evidence of a lack of attention on disinfection in the first half of the century, this does not tell the entire story. As Pelling has identified, there was criticism that commercial disinfectants were quack preparations that detracted from more important aims such as cleanliness.⁷⁷ This did not, however, result in the rejection of disinfection. Evidence of hostility to commercial disinfectant does not equate to dismissal of the whole concept. There was lively, ongoing debate about the theory and practice of disinfection, and it is striking how commonly disinfection appeared in medical journals.⁷⁸ Authors also increasingly made positive statements about disinfection's ability to prevent disease. These opinions became more pronounced from the 1840s, demonstrating the inclusion of disinfection within accepted disease prevention measures.⁷⁹

Interest in disinfection expanded dramatically during the mid-1860s. The eruption of both cholera and cattle plague in 1866 made disease prevention a top priority.⁸⁰ Hardy has argued that these diseases in particular were significant in developing ideas about how to "stamp out" disease, and the resulting systems of disease control.⁸¹ These included processes of isolation, disinfection, and case tracing. The outbreak also arguably produced the first systematic enquires undertaken on behalf of Parliament regarding the worth and operation of disinfection.⁸² These contained details of how disinfection had been applied to the disease, and so drew attention to disinfection.⁸³ Some of the texts concerning cattle plague were also reproduced for publication.⁸⁴ Robert Angus Smith's 1867 work *Disinfection and Disinfectants*, which drew on his cattle plague research, was perhaps the first comprehensive monograph on disinfection.⁸⁵ The book was not

universally well received, but nevertheless illustrates the heightened importance of disinfection.⁸⁶ Alongside these texts the number of articles concerning disinfection increased dramatically, as did discussions of disinfection in other books. The visibility of disinfection was clearly increasing.

The impact of the new debates can perhaps best be shown by comparing various editions of Parkes' *Manual of Practical Hygiene*, the standard text of the period.⁸⁷ The first two editions, published in 1864 and 1866, had minimal content on disinfection, and it was seen as incidental to other matters.⁸⁸ However, by the third edition in 1869 an entire section on disinfection had been added, discussing the nature of infection, disinfection technique, and citing work by Crookes on the cattle plague as evidence for combating human diseases.⁸⁹ Parkes also claimed that "disinfectant" was now in popular use.⁹⁰ The turning point can be clearly identified in the mid to late 1860s. This was reflected in the 1866 Sanitary Act, which was the first public health measure to include significant powers for disinfection.⁹¹ The act gave local authorities the power to set up disinfection chambers, and to disinfect houses, objects and public places; these powers were the basis of local authority disinfection for the rest of the century.

Definitions of disinfection were also put forward. At the most basic level it was seen as the process of preventing infection, irrespective of what this was or how it had appeared.⁹² Identifying the nature of this "infection" was more problematic. There were varying definitions, encompassing different combinations of disease causation theory; nevertheless, all envisaged that there was a tangible product of a process, infection, which could be disinfected.⁹³ This supports Baldwin's claim that disinfection fitted into different concepts of disease causation.⁹⁴ There were some trends in definitions. One matter of changing concern was whether smells were disease-causing 'miasma'.⁹⁵ If they were, then deodorisation was disinfection and a valuable disease prevention tool.⁹⁶ As the equation of smell and miasma broke down from the 1830s onwards, deodorisation

was excluded from disinfection and regarded as misleading.⁹⁷ Emphasis on the role of putrefaction also changed over time. Putrefaction had been implicated in disease causation throughout the century, and its importance was increased by Liebig's 1840s work on decomposition.⁹⁸ Disinfection was thought to act on the products of putrefaction, and there were debates about whether it acted on the process itself; this uncertainty lasted until the 1860s.⁹⁹ This shows that disinfection was a fluid and complex concept even in the first half of the century.

Theories and concepts of disinfection in an age of transition: 1870-c.1880

The following three sections examine changes in concepts of disinfection alongside the development of germ theories. The first section investigates the ways in which disinfection theory reacted to changing ideas about disease between 1870 and 1880s. In this period, germ theory was being constructed, and disinfection was attempting to assimilate and understand new ideas. The next section examines the establishment of a consensus on the relationship between germs and disinfection in the 1880s. As germ theory became more certain, the equation of disinfection with germicide became mainstream. The third section examines the period after 1890, when most writers were confident that disinfection was germicide. There was, however, still dissent, concerning what should be excluded from as well as included within disinfection. In this way, germ theory was able to transform thinking on disinfection, although complexities and ambiguities remained.

Ideas about disease were in a period of transition in the 1860s and 1870s. There was a range of approaches to disease causation, with many doctors actively avoiding "theory" and relying on empirical evidence.¹⁰⁰ Delineating a clear consensus on what "disease theory" was is therefore problematic. Nevertheless, it is possible to identify broad changes in thinking about disease causation, particularly the development of "germ theory". Late nineteenth century commentators certainly believed that these ideas had revolutionised the way disinfection was approached.¹⁰¹ Worboys has investigated the rise of germ theories from the 1860s onwards and charted their varying influence on different fields.¹⁰² Such approaches initially dealt with the problem of defining where

complex chemicals ended and life-forms began, but then moved on to considering questions of disease prevention such as whether germs were alive, whether they developed de novo, and whether they actually caused diseases.¹⁰³ These debates then started to influence the thinking of ordinary medical practitioners. Worboys argues that germ theory initially came to the attention of many medical practitioners in the late 1860s in connection with Listerian antiseptic surgery, despite evidence that application of the idea of germs in antiseptic surgery was not straightforward.¹⁰⁴ Whilst germ theory has been seen by some as a major turning point in public health, the spread of germ theories in public health was arguably somewhat slower than in other branches of medicine, and more complicated than initially thought.¹⁰⁵ In this way, germ theories were apparently starting to have an impact, albeit a complicated and unpredictable one, on thinking about most aspects of public health from the 1870s onwards. This section therefore examines the development of concepts of disinfection between c.1870 and 1914, using texts on disinfection, disease transmission, hygiene and other related topics to explore the differing and competing definitions that were in play. The discussions show that there was significant change in the nature of disinfection theories after germ theory was accepted, but that these do not tell the whole story of the complexity of its effects.

Evidence of the direct impact of germ theory on disinfection texts can be seen in terms of specific discussion of the theory, even where the text was unsure about the legitimacy of the ideas. Worboys has argued that, after 1865, pre-germ practices such as disinfection were increasingly recast as “germ” practices, and that this trend was evident by the 1870s.¹⁰⁶ This can be seen in the literature although there are complexities in the relationship between germs and disinfection. Some authors took a clear and definite approach to disinfection and how it should relate to germs. A common theme was the need for disinfection to kill germs. For example, in 1873 E. Smith’s *Manual* claimed that disinfectants should destroy protoplasmic and germ life.¹⁰⁷ Nevertheless, in discussing the shortcomings of some disinfectants he also mentioned that some failed because they allowed germs to develop, indicating that he also included inhibiting germs within disinfection. Others agreed with this exclusive definition and emphasised the need to

concentrate only on killing germs. T. Bond claimed that other processes were “too easily confused” with the permanent destruction of life, and only this should be regarded as disinfection.¹⁰⁸ The early impact in the 1870s of germ-based ideas over definitions of disinfection is clear.

Germ ideas could also have purchase without being clearly articulated. Other authors made statements which seem to have been similar in intention but were structured in vaguer terms. J. H. Timmins claimed that “disinfectants are substances that are capable of destroying the specific poisons of infectious disease”.¹⁰⁹ “Specific poisons” could be taken to mean several things, but it is clear from the rest of the text that Timmins primarily identified these poisons with germs. This was not an individual foible, and other statements which discussed “disease poisons”, but which evidently meant something with the characteristics of a germ, appeared over the decade.¹¹⁰ This can be read as a way of associating earlier ideas about the existence of specific miasmas, produced by putrefaction, with germs; it was thought that the germs caused the poisons and this was the mechanism whereby disease occurred. Concepts which included a role for germs were thus not always expressed in the language of germs. Some commentators were also non-specific in the actions they thought disinfectants should be capable of achieving on germs.¹¹¹ Others specified that disinfectants should be able to inhibit, rather than kill, the germs. J. Dougall argued that it was not necessary to kill germs, and indeed that the sheer numbers of them in the environment made it impossible to do so.¹¹² Instead, germs should be prevented from developing, or persuaded to relocate elsewhere by making their environment unpleasant.¹¹³ Nevertheless, he listed killing germs as a benefit of some disinfectants.¹¹⁴ For Dougall, microscopic life could be targeted in a number of ways. These different texts demonstrate that a germ-focussed approach did not necessarily involve killing them, and that a range of other possibilities was considered.

The continuing importance of older explanations of disease is also evident in definitions that blended notions of killing or targeting germs with established disinfection

ideas. G. Wilson, writing in 1879, added a discussion of germ theory to the 4th edition of his *Handbook of Hygiene*, listing it alongside explanations that focussed on antiseptics, fixing of disease-causing agents and deodorisation.¹¹⁵ Although he was sceptical about the significance of aspects of germ theory, its inclusion demonstrates the extent to which it was influential even for sceptics. Other texts continued this blended approach. In 1879, W. Fleming Phillips, while claiming that disinfection was the “destroying or counteracting of infection”, also claimed there were still benefits to deodorisation and antiseptics as disease-causing germs could find putrefaction and bad smells useful for their growth.¹¹⁶ Whether he thought these aspects should be included within disinfection is unclear, but the emphasis on a wide disease prevention programme is evident.

Some, however, were less convinced by the notion of germs having any role in disease causation and thus in disinfection. Authors could believe in the presence and activity of germs, and the need for generalised disinfection, without thinking that germs caused disease. Statements of this type appeared in several texts in the 1870s, including those by J. Drysdale, E. Parkes and L. Beale.¹¹⁷ If germs did not cause disease then disinfection must act in other ways. Descriptions of disinfection as the ability of a substance to stop putrefaction continued throughout the 1870s. This built on the work of Robert Angus Smith, which assumed that halting or destroying the action of germs associated with putrefaction was the aim of disinfection. Several texts from the 1870s stated that disinfection should be concerned with halting putrefaction.¹¹⁸ This could include a focus on the products of putrefaction as well as putrefaction itself.¹¹⁹ Such definitions often characterised disinfection as deodorisation or oxidation of the gases, but saw putrefaction as their root cause. Other approaches appeared to focus on putrefaction but actually used germs as the underlying explanatory factor. It is worth considering examples of this in detail as they illustrate the complexity of different viewpoints on disinfection.

A good illustration is Arthur Sanson’s *The Antiseptic System*, published in 1871.¹²⁰ On the face of it Sanson’s arguments show a clear focus on putrefaction: he

argued that carbolic acid was an effective disinfectant due to its ability to halt decomposition.¹²¹ On the other hand he also ascribed to carbolic the power to “instantly” kill “bacteria, vibrios, spirilla, amobae, monads, eugleniae, paramecia, rotiferae and varicellae”, provided it was used in strong enough concentration.¹²² This was a comprehensive list of types of microscopic life, emphatically underlining that disinfection could deal with germs. The list also demonstrates that Sanson did not concentrate exclusively on bacteria. This was mirrored by other contemporary texts which discussed actions of disinfectants on yeasts and other species.¹²³ Sanson combined these two arguments by claiming that it was these micro-organisms that caused putrefaction and turned organic matter into the inorganic products of decomposition; he therefore thought that disinfection was the “destruction of the disease-producing agents which give rise to those affections known as zymotic”.¹²⁴ This showed continuity with older ideas about the role of fermentation in producing disease-causing miasmas within and outside the body. He also thought that disinfectants could act on the poisons of infectious diseases, mentioning vaccine lymph in particular as an example of this.¹²⁵ Sanson was not specific about what these were, but it seems from the rest of his framework that these poisons were thought to be associated with germs. It was also apparently important to understand whether disinfectants acted by the former or the latter methods.¹²⁶ Sanson, therefore, focussed on putrefaction but also included both inhibitive and destructive actions within disinfection, whilst still seeing germs as the root cause of the problems. Similar ideas appeared in other texts and drew on wider notions about putrefaction and its causes, linking disinfection to concepts of antisepsis and fermentative diseases.¹²⁷

Deodorisation also appeared in definitions of disinfection, both in relation to putrefaction and to germs. Some texts specifically included deodorisation within disinfection, although this was rare.¹²⁸ Other definitions took a hybrid approach to the three processes. In 1871, an article in *The Times* claimed that disinfection dealt with the

gases produced by putrefaction, and thus disinfectants needed to be gaseous.¹²⁹ This explanation linked disinfection to decomposition, identifying that the means by which disinfectants were to act was on gases, by gaseous means. This focus on the role of gases reflected earlier statements about disinfection and demonstrated their persistence. Other definitions from this period indicate the merging of older ideas about deodorisation with germ theory. In the 1870s C. Cameron was a key proponent of hybrid ideas; his theories can be explored in his two main works, *The Prevention of Contagious Diseases* and *A Manual of Hygiene*. Cameron gave a three-part definition of disinfection, claiming that the term in the wider sense meant all substances that prevented putrefaction or rapidly destroyed decomposing organic matters, foetid gases and vapours.¹³⁰ He thus included processes that were commonly regarded as antiseptics and deodorisation within disinfection, demonstrating a wide-ranging and flexible approach to disinfection. The influence of new ideas can, however, also be seen in his work. Cameron stated that only some of these antiseptics and deodorisers also had the power to kill bacteria, and if it was found that the germ theory of contagion was true, then the more the ability of disinfectants to kill germs, the greater their sanitary value.¹³¹ In this way, whilst he included germs within a broader conception of disinfection, Cameron also recognised that many different disinfectants, antiseptics and deodorants were in use, and it would be of great practical importance if their relative properties were clearly ascertained.¹³² This statement shows that Cameron allowed new research to affect his ideas. The 1870s, therefore, saw a wide range of possibilities for disinfection, with no systematic differences between popular, specialist and professional texts. This shows how disinfection theory could simultaneously be influenced by a range of differing ideas about disease causation.

Bacteria, germs and disinfection: establishing a consensus, 1880-1895

The move towards incorporating germ theory into concepts of disinfection progressed in the 1880s. Worboys and other authors have argued that after 1880 there was a growing consensus that disease germs were bacteria, and about their properties and the ways they spread disease.¹³³ Research by figures such as Koch identified the particular

bacterial causes of several diseases, inspiring confidence in the validity of bacteriology.¹³⁴ As bacteriology grew stronger its influences on disinfection also became more pronounced. The equating of disinfection with killing germs grew in importance during the 1880s. In 1881, J. Tyndall argued that there was a need to concentrate on germs in order to prevent disease, and that their nature needed to be known in order to kill them.¹³⁵ This set the tone for the rest of the decade. Many authors focussed on the need to destroy bacteria, and made statements to this effect.¹³⁶ There is also evidence of shifts in attitude from some who had favoured a more inclusive definition of disinfection. G. Wilson, in the 6th edition of his *Handbook of Hygiene*, published in 1886, changed his approach to defining disinfection. He claimed that although previously disinfection had been used vaguely to include antisepsis, deodorisation and fixative processes, strictly it meant dealing with germ-based contagion.¹³⁷ This is revealing, as previously Wilson himself had taken this “vague” approach. Wilson’s changed views show the wide impact that germ theory was having on ideas underlying public health practices. The specificity that would colour later approaches to disinfection also started to appear more forcefully in this decade. For some, destruction of infection was the only basis on which disinfection should proceed. Writing in the same year as Tyndall, George Buchanan laid out a simple standard for true disinfection.¹³⁸ It was “the destruction of the most stable known infective matter”, meaning germs.¹³⁹ The idea of disinfection as germicide followed hot on the heels of the new bacteriological research.

This narrowed focus on killing germs was not the only theory considered. Others were less confident about the need to kill germs, instead continuing to deal with them in an unspecified way. These statements were most common in texts aimed at popular and public disinfection. *Hints on How to Avoid Fevers*, published in 1884, discussed the importance of germs at length and implied that disinfection involved dealing with germs whilst making no definite statements about what it would do.¹⁴⁰ A new edition of Mrs. Beeton’s *Book of Household Management*, published in 1888, also included an enlarged section on contagion and an explanation of germ theory, making it clear that the

processes of disinfection described were aimed at germs.¹⁴¹ There was no clear mention, however, of whether this action was to kill germs or deal with them in some other unspecified way. These non-specific mentions of controlling germs shaded into other definitions which included inhibiting germs, but did not focus on destroying them. Discussions of this type also appeared in texts aimed at medical practitioners as well as in popular publications. R. Robson Roose, writing in 1888, thought that whilst bacterial disease causation was a popular theory, its exact relevance had not yet been fully defined.¹⁴² He took a more inclusive approach to disinfection, stating that “any substance may be regarded as a true disinfectant which, when added to a quantity of fluid swarming with bacteria, abolishes the reproductive power of these organisms”.¹⁴³ This statement could be interpreted in a number of ways to include temporarily or permanently preventing the organisms replicating themselves, killing the bacteria, or changing their environment. Nevertheless, the use of the word “reproductive” here seems to indicate that Roose was thinking mostly about inhibiting germs. Roose was also unsure about how bacteria were involved in disease causation; whilst he thought that the case for organic matter rather than noxious gases being the cause of disease had been fairly well backed up, he was unconvinced that the link between bacteria and disease had been proven.¹⁴⁴ He did, nevertheless, discuss the need to kill germs when recommending particular methods of disinfection.¹⁴⁵ Roose’s statement that disinfection and infection were both loosely defined terms which could be used in a number of ways seems apt.¹⁴⁶ In this way the action of germs could be approached in terms of stopping them acting, rather than killing them outright.¹⁴⁷ Processes of antisepsis could thus still be regarded as disinfection.

The themes of putrefaction and oxidation common in the mid-century also continued to be applied to disinfection, and were increasingly coupled with ideas about germs. This is perhaps not surprising given the genesis of ideas about germs in relation to putrefactive and fermentative processes. It did, however, strengthen the possibility of antisepsis and other processes remaining within disinfection. A range of texts discussed the importance of decay in disinfection. Some classed substances that halted putrefaction

as disinfectants. Weatherly, writing in a popular health tract of 1880, claimed that disinfectants were substances that destroyed the infective power of germs, or indeed of any putrefactive matter.¹⁴⁸ This two-part definition shows the continuing influence of ideas of putrefaction and the associated concept of zymosis, as well as the influence of germ theory. These ideas appeared in other texts.¹⁴⁹ Some, however, took a stronger position. In 1882, A. Wynn Williams argued that the only true disinfectants were those that hastened putrefaction. His reasoning for this was interesting. He claimed that these substances were effective because they hastened the death and decomposition of germs.¹⁵⁰ Whilst his definition focused on putrefaction, this was clearly aimed at germs. In this way, his approach to disinfection was based on earlier ideas but had been clearly influenced by notions of killing germs.

Oxidation, which had previously been seen as a means of hastening putrefaction and decomposition, showed a similar move towards hybridised definitions. T. Hatfield Walker saw oxidation as a key part of disinfection. He divided disinfectants into two categories: those that kill microbes and those that set free nascent oxygen or ozone.¹⁵¹ For Hatfield Walker, therefore, killing germs was one aim whilst the release of oxygen, which would speed up the decomposition of any disease-causing agents, was an alternative. The idea also appeared in other texts. A home nursing text from 1888 also suggested that oxidation was involved in disinfection. The author claimed that there were two types of disinfectants. The first type killed the germs outright, which is entirely in line with other definitions of disinfection in this period. The other category, however, shows a very different focus. This referred to substances that rendered germs harmless by combining oxygen with “those deleterious gases in which the germs flourished”.¹⁵² This focus on oxidation as a way to remove conditions favouring bacteria shows the continuing influence of older ideas, even where germs were also discussed. A range of alternative ideas thus continued to be used well into the 1880s alongside one another, demonstrating both the influence and the limits of germ theory.

Some authors remained unconvinced by germ theory and specifically with the idea that disinfection needed to kill germs. One such author was de Chaumont, who took

over editing and rewriting Edward Parkes' popular *Manual of Hygiene* in the 1880s.¹⁵³ His works provide an interesting insight into how far a well-respected hygiene manual with wide readership could differ from leading scientific debates about disinfection. A general discussion of germ theory first appeared in the book in the 1873 edition, although it was not approached in a particularly positive manner. The text then went through several editions, allowing us to trace the changes in approach. In the 1883 edition de Chaumont added to the section on germs. He was unsure about the exact causation of disease, but discussed the implications if various types of micro-organism were found to be the cause. He made a distinction between bacteria and "bioplastic contagia", stating that bacteria were more difficult to kill. This made disinfection potentially a much more involved process. On the other hand, he also argued that it was possible that disease-causing bacteria, which would be the focus of disinfection, were easier to kill than putrefactive bacteria, making the process easier.¹⁵⁴ For de Chaumont, therefore, the germ theory of disease was as yet unproven, and the remedies it would indicate were potentially problematic. By the 1887 edition he was still unsure whether bacteria caused all diseases, although he acknowledged that research had shown that they caused some. Nevertheless, his scepticism extended to what counted as disinfection. He believed that investigations that looked only at killing bacteria presupposed they caused disease, and this was not yet proven. Disinfection practice should thus rest on experimental evidence gleaned from actual practice, rather than limited laboratory based experience.¹⁵⁵ It is interesting that de Chaumont saw killing germs as the necessary response to the concept of germs as the cause of disease: this is in line with the main discussions of germ theory but was not necessarily the only way germs could be managed.

The complicated ideas of C. T. Kingzett, the manufacturer of Sanitas disinfectants, can be used to illustrate continuing ambivalence towards germ theory.¹⁵⁶ Kingzett thought that bacteria only indirectly caused disease; it was the chemical poisons they secreted that were the real cause.¹⁵⁷ This echoed ideas put forward by other authors, who saw the new serum therapies which countered the toxins of tetanus and diphtheria as methods of disinfection.¹⁵⁸ For Kingzett, therefore, bacteria were not the problem in

themselves, but the source of unspecified disease poisons: he thus utilised germs to illustrate pre-germ ideas. He was also sceptical about killing germs. Kingzett argued that too little was known about germs in order to “conquer” them. He also suspected that it was practically impossible to annihilate all disease-causing microscopic life.¹⁵⁹ For this reason, it was acceptable just to inhibit the bacteria and stop them producing their products and, therefore, any substance which restrained germs was a reliable antiseptic and a true disinfectant. Nevertheless, Kingzett also hedged his bets and emphasised the ability of certain disinfectants, in particular his own products, to kill germs. Kingzett’s work thus showed considerable fluidity between various approaches to disinfection. His system was clearly influenced by new ideas about germs, perhaps just as a cynical marketing ploy, but also relied on earlier ideas about poisons and their environments. He also emphasised the point that a germ-centric approach would not necessarily result in the definition of disinfection as germicide; other approaches were possible. As Worboys has argued, the emergence of a bacteriologically-focussed germ theory was not a foregone conclusion, and other possible ideas could have triumphed: applying this insight to disinfection illuminates the proposition that the inclusion of germ theory within disinfection did not necessarily lead to disinfection being defined as killing germs.

A new definition: germ theory triumphant, 1890-1914.

As time progressed germ theory became even more influential. Many authors writing in the 1890s thought that it had been almost universally accepted. I. White Wallis, writing in 1894, claimed that germ theory was now generally believed.¹⁶⁰ T. Dutton, in a book aimed at the middle class market, published in the same year, made a similar statement, and claimed that germ theory was now accepted.¹⁶¹ Whilst this may have overstated the case, the 1890s were of crucial importance in the continuing dissemination of and confidence in germ theories.¹⁶² Cunningham has argued that germ theory meant a step change in thinking about the causes of disease; after its advent, each disease had a single, unique material cause which was identifiable only in the laboratory. This had important implications for disinfection.¹⁶³ Germ theory debates and the redefining of disinfection continued hand in hand. Statements about disinfection and germicide can be

seen in published texts throughout the decade, in both popular and professional books. In 1890, A. Wynter Blyth defined disinfection simply as germicide.¹⁶⁴ This statement was standard throughout the decade, with most bacteriology or disinfection texts specifying this was the case.¹⁶⁵ Similar ideas were also standard in manuals of public health.¹⁶⁶ For instance J. Dowling, writing in 1897, emphasised that disinfection meant the complete destruction of disease germs, and that if a substance did not meet these conditions then it could not be called a disinfectant.¹⁶⁷ The clarity of purpose in these explanations is obvious and demonstrates the extent to which disinfection had become germicide. Works aimed at the public gave similar definitions of disinfection, although such ideas appeared with less regularity than in other types of texts.¹⁶⁸ The gap between professional and popular representations of disinfection widened in the 1890s, with implications for the implementation of policy.

There is also evidence of authors becoming more convinced about the importance of germ theory. In the 7th edition of his *Handbook of Hygiene*, 1892, G. Wilson defined disinfection as killing “contagion”, which he then specified was germs or bacteria.¹⁶⁹ This completed his shift from espousing antiseptic, deodorant and fixative aspects of disinfection in 1873 to seeing disinfectants as germicides by 1892. J. Lane Notter, editing the 8th edition of Parkes’ *Manual of Practical Hygiene*, altered the text so that it was much more definite about the role of germs in disease causation than earlier editions.¹⁷⁰ They had previously discussed various theories of disease causation as “current” ideas. In this edition, however, they were referred to as believable “until recently”. Nevertheless, Lane Notter still rejected any research that was only based on bacteriology, although he thought that it was a crucial part of disinfection.¹⁷¹ This demonstrates that the need to “kill germs” was by no means completely accepted even by those who were moving closer towards supporting germ concepts of disinfection. Some texts were vaguer about the terminology, but seem to have seen germs as their target. A. Davies, writing in 1895, discussed disinfection exclusively as killing living contagia rather than germs, although

in later chapters he implied he thought that these were bacteria.¹⁷² Even where authors did not explicitly state it in their definitions, germs or bacteria were usually the focus of their disinfectant attacks. Other texts continued to contain references to disease poisons but a closer reading demonstrates that they were referring to what others would have termed “germs”.¹⁷³ Germ concepts could be deployed even where the language was not invoked; the use of differing terms also highlights that germ theories had not become hegemonic.

The question of which micro-organisms were targets was also considered. Worboys has argued that a bacteriological germ theory was not inevitable.¹⁷⁴ This is evident in disinfection texts, and whilst most authors made it clear that they were discussing bacteria, their definitions used the vaguer term “germs”. This could be taken to indicate that authors recognised the importance of other forms of microscopic life in disease causation. Their approach to diseases where no causal organism had been identified, however, shows that this was not the case. Several common infectious diseases, which contemporaries were aiming to deal with within a bacteriological framework, are now known to be caused by viruses, so that bacteriology was not able to identify a causal agent for these diseases.¹⁷⁵ Lack of a causal bacterium was not often mentioned in the debates about disinfection, although it could be seen to have been alluded to in discussions that identified a causal agent for some, but not other, infectious diseases.¹⁷⁶ Some authors did, however, discuss general principles for dealing with cases where the causal agent of the disease was not known. For instance G. Nuttall, writing in 1893, discussed the application of disinfection to diseases where the pathogenic organism had not been identified. He thought that evidence based on disinfecting known diseases could be applied to unknown diseases, provided it was done thoroughly.¹⁷⁷ Unknown agents were thus assumed to be like known agents, and were thought to be bacteria. Similar sentiments appeared in other texts, demonstrating that whilst the issue was not considered particularly often those who did write about it also thought that bacteria were the cause of all diseases.¹⁷⁸ Disinfection theory thus increasingly concentrated solely on

bacteria, excluding the wider approaches discussed in the 1870s and further excluding other concepts of disinfection.

With disinfection defined as acting on germs, new questions were raised. Did disinfection act solely on specific disease-causing agents, or was it more generalised? Some authors claimed that not all bacteria should be killed, making a widespread approach to disinfection unhelpful. For example W. Russell, writing in 1878, claimed that some bacteria were harmless, and thus it was unnecessary to kill them.¹⁷⁹ These statements continued to appear over the next few decades and were common in both popular and professional texts. Authors of popular works emphasised that not all encounters with germs necessarily led to disease, reassuring their readers that germs could be beneficial as well as dangerous.¹⁸⁰ Similar debates appeared in medical and professional advice texts. These were usually more sophisticated in outlook, pondering whether sterilization, or the destruction of all germs, was an acceptable aim. For some, disinfection and sterilization were synonymous. S. Rideal claimed that after the rise of germ theory disinfection ceased to mean purification and acquired the special meaning of sterilization.¹⁸¹ He was, however, unusual in equating the two.¹⁸² Other texts aimed at medical professionals followed popular works in drawing definitional lines between specific action and generalised germ massacre. For some, disinfection could be aimed at any undesirable bacteria; whether they were pathological was unimportant.¹⁸³ It was, however, more common to define disinfection as acting only on pathogenic bacteria. S. Delepine, for instance, claimed disinfection aimed to destroy disease-causing microbes only.¹⁸⁴ Sterilization, on the other hand, aimed to kill all bacteria, including those that caused decomposition.¹⁸⁵ Disinfection was the destruction of specific disease-causing bacteria associated with a known illness; this was necessary to prevent the spread of disease in a public health context. Sterilization was the destruction of all bacteria, and was utilised for surgery and other processes where any bacteria could cause problems.¹⁸⁶ They were practices with different aims. Conversely, other authors thought that it was impossible to kill all bacteria, meaning that for pragmatic reasons alone disinfection

should concentrate on disease-causing bacteria.¹⁸⁷ This specificity resulted from the new ability to identify individual disease-causing species of bacteria, and furthered the increasingly particular definition of disinfection emerging in the 1890s. This links to H. Cunningham's argument that laboratory methods led to the transformation of the identity of infectious disease from a collection of clinical symptoms to a specific type of bacteria.

¹⁸⁸ For whatever reason, disinfection could not be regarded as a generalised process of killing all germs.

Differences in resistance between types of micro-organism were also highlighted by some authors. Statements comparing the differing resistance of forms of microscopic life had appeared in texts in the 1870s and had initially been a means of undermining the case for germ-focussed disinfection. W. Fleming Phillips, writing in 1879, thought that it was not safe to assume that just because one substance killed harmless germs it was also able to kill malevolent germs.¹⁸⁹ De Chaumont also made this distinction, hypothesising that disease bacteria might be easier to kill than putrefactive bacteria, and thus disinfection could be easier than he had first assumed.¹⁹⁰ By the 1890s, however, some authors had reversed this distinction. J. Gay also thought that generally the disease-producing germs had the least resistance of all.¹⁹¹ There were, however, countervailing tendencies that complicated matters. Spores were regarded as problematic by some commentators. These debates originated in the 1880s, as research by bacteriologists such as Koch and Klein highlighted the superior resistance of spores.¹⁹² This had particular implications for disinfection; if spores were able to resist disinfection processes then they posed a significant risk to public health. Some commentators thus called for disinfectants to be judged on their ability to kill spores as well as germs.¹⁹³ These statements became commonplace in specialist bacteriological and disinfection texts from the 1890s onwards. Such comments were, however, uncommon in most professional texts and rarely appeared in popular works. Whilst spores could be considered an important additional problem they were not part of the normal conception of disinfection.

Given that there were great differences in behaviour between species, the

standard bacterium for disinfection was a moot point. In 1884, Sir George Buchanan laid out a simple standard.¹⁹⁴ Disinfection was “the destruction of the most stable known infective matter”.¹⁹⁵ George Newman, writing fifteen years later, claimed this was difficult to achieve, but was nevertheless the only satisfactory approach.¹⁹⁶ The importance of destroying the most resistant bacteria was repeated in other texts aimed at medical professionals.¹⁹⁷ These high standards had several implications for disinfection practice and testing disinfectants, as we will see later. This was not a concern for popular works, which concentrated on informing the public about specific common diseases. The disparity between these categories of texts is striking, and demonstrates the extent to which more “practical” disinfection advice diverged from cutting-edge disinfection research during the 1890s. The debates about the nature of disinfection demonstrate that whilst the focus on “killing germs” could seem simple, definitions were elusive and different authors approached the matter with varying degrees of rigour. Defining the germs which were the subject of disinfection was not straightforward even within a bacteriological theory.

As we have seen, disinfection theory increasingly focussed on killing germs. This was not, however, exclusive even after 1890, and some authors continued to approach disinfection more widely. G. Sims Woodhead, writing in 1891, defined disinfection as killing germs.¹⁹⁸ Nevertheless, in 1966 – Monopolies Commission – detergent giants Unilever and P&G should reduce their prices by an average of 20% and the advertising expenses by 40%. Next, he stated that a proper understanding of putrefaction was a key underpinning of any knowledge of the role of organic poisons in causing disease.¹⁹⁹ In this way he extended his ideas to include inhibiting other microscopic life as well as simply looking at killing germs. M. Truman and E. Sykes, authors of a text covering the nursing of infectious cases, had some novel thoughts about disinfection.²⁰⁰ They maintained that disinfection, antisepsis and deodorisation could be defined differently and were separate processes, and claimed that disinfection was “the destruction or rendering harmless of organic matter capable of communicating disease”.²⁰¹ This was in line with

wider ideas; nevertheless, the addition of “rendering harmless” opened up the possibility that other actions, such as fixing and inhibiting the contagious matter, could also be regarded as disinfection, in opposition to many of the exclusive definitions encountered in other texts. They also claimed disinfectants could have beneficial actions beyond simply killing germs.²⁰² In this way, although they maintained the distinction, they did not stick to the strict emphasis on germicide that other authors championed.

Others followed this tack and acknowledged the possible gap between theory and practice. W. Noble Twelvetrees argued that although disinfection should mean killing germs, in practice it included other processes. These included: providing physical conditions unfavourable to bacteriological growth; using agents that caused changes in germs and any volatile disease poisons; and substances that absorbed harmful elements.²⁰³ While Twelvetrees understood the technical definition, his willingness to include within his definition methods which prevented the spread of disease rather than only those that killed the disease-causing germs shows that disinfection in theory and in practice differed for some authors. Other comments demonstrate the same slippage in terms of efficacy rather than conceptual unity. C. T. McKintock claimed that corrosive sublimate was not a germicide. Nevertheless, he still thought it was an effective disinfectant as it was also a strong antiseptic.²⁰⁴ This also shows that while germicide was seen as the standard definition for a disinfectant, other, practical applications could change this idea.

The definitional separation of disinfection from other processes was strengthened throughout the period after 1900. There was also recognition among contemporaries of the shift in thinking about disinfection that had resulted from the development of ideas about germs. S. Rideal, writing in 1903, set out a clear assessment of the impact of changing ideas.²⁰⁵ He claimed that after the advent of germ theory, disinfectants became increasingly equated with germicides. By 1900, it was expected that a disinfectant would go to the source of the trouble by killing the organisms, thus preventing the spread of epidemic disease.²⁰⁶ Many authors agreed with this and defined disinfection as the process of “killing germs”. As in earlier decades many examples of this approach can be

found in a variety of texts.²⁰⁷ These definitions formed the dominant approach to disinfection after 1900, and this increasing equation of disinfectants with germicides unsettled which substances were regarded as effective.²⁰⁸ This shows that whilst, as Baldwin has argued, disinfection could be fitted into many systems of disease control, the nature and approach to what was being done was very different according to the dominant theory. In this way, although germ theory had resulted in significant and widespread changes in the way disinfection was conceptualised, the origin and direction of these changes was in line with those occurring earlier in the century. By changing the definition of infection, disinfection could be redefined with little difficulty.

There were still some voices of dissent. In 1909, Sanitas owner C. T. Kingzett commented that disinfection was not simply about killing germs, and thus “germicide” and “disinfectant” were not synonymous.²⁰⁹ He claimed that disinfection should also include situations where bacteria remained present, but “their baneful changes had been prevented”.²¹⁰ This view was long held: in 1885, Kingzett claimed that disinfectants needed to deal with the chemical products of bacteria as well as the bacteria themselves, as these were the cause of some diseases.²¹¹ It is difficult to get information on the training and background of Kingzett. He had, however, undertaken his own bacteriological research and maintained a healthy intellectual interest in bacteriology and disinfection, meaning that it would be unwise to dismiss him as an amateur or popularist. This view was backed up by other texts. In 1910, a speaker at the British Pharmaceutical Conference claimed that true disinfectants decomposed the products of bacteria, as well as killing them.²¹² The *Chemist and Druggist* also agreed that the substances produced by bacteria were important.²¹³ Others continued to link germs and putrefaction to definitions of disinfection. F. Andrewes, in 1903, discussed the chemical activities of bacteria, including putrefaction.²¹⁴ In this way, although theoretical texts increasingly defined disinfection solely as germicide, other texts continued to recognise other approaches, often in an inconsistent and confusing manner. The idea that antisepsis could be disinfection in some circumstances, and that there were chemical products of bacteria

that needed disinfecting, was at odds with most of what was written on disinfection, but demonstrates that its definition could not be totally settled. The range of authors involved in such dissenting opinions shows that it was not only those writing for a popular audience who took a broad approach to disinfection; medical professionals and those with an interest in bacteriology also disagreed with the emerging, dominant mode of thought. This is in line with Worboys' wider conclusion that some doctors and researchers continued to disagree with different aspects of germ theory throughout the period and utilised other concepts of disease.²¹⁵ Nevertheless, dissenting authors saw disinfection as important and used many, if not all, the same points of reference as mainstream authors, but did not necessarily come to the same conclusions about the relationship between theory and practice.

Antisepsis, deodorisation and disinfection

As well as disinfectant being seen as germicide the processes of antisepsis and deodorisation were also increasingly separately defined and specified. Antisepsis and deodorisation were characterised as different from disinfection, with independent roles.²¹⁶ Separate definitions started to appear in the 1870s, continuing in some medical texts in the 1880s, and becoming more common in the 1890s.²¹⁷ Many authors started with a straightforward tri-partite distinction defining disinfection, antisepsis and deodorisation. These statements appeared in bacteriological and disinfection texts aimed at medical professionals, and became a standard feature by 1900.²¹⁸ Similar ideas also appeared in texts with a wider remit, including manuals of public health and nursing texts.²¹⁹ These views had sufficient reach that they became common in popular health tracts after the 1890s, although as with other ideas they appeared somewhat later in this literature than elsewhere.²²⁰ The distinctions between the three processes backed up the definition of disinfection as germicide. They were not, however, made in all popular texts, and appeared less frequently than in professional works. This reflects the tendency of popular authors to be less precise when defining disinfection.

Definitions of antisepsis and other processes emphasised the exclusive nature of disinfection. Most definitions of antisepsis saw it as halting the action of germs rather

than killing them.²²¹ Antiseptics were also seen as having the power to stop putrefaction through unspecified means or by acting on the germs that caused it.²²² Authors frequently mentioned germs but we cannot infer that all references to putrefaction meant that the author believed antiseptics inhibited germs. Texts aimed at bacteriologists and medical practitioners tended to discuss the action of germs whereas more general works couched their definitions in relation to putrefaction. These were two sides of the same coin. Antisepsis was increasingly defined separately whereas in the 1870s and 1880s it had been included within disinfection. Assessments of the relationship between antiseptic and disinfectant powers backed up this conceptual separation. Some commentators thought that disinfectants were usually antiseptics, but stressed that the reverse was not always true.²²³ These views were common between 1870 and 1914.²²⁴ Some authors allowed a relatively positive bi-directional relationship between the two properties. G. Newman, writing in 1899, thought that a strong antiseptic might act as a disinfectant, and a weak solution of disinfectant as an antiseptic.²²⁵ There was, however, little explanation of exactly why these relationships might occur.

It is important to consider how disinfectants were thought to operate. By the late 1890s there were three main theories. In most texts the assumption was that disinfectants were poisonous to germs.²²⁶ Other explanations focussed on the ability of chemicals to coagulate organic matter, changing the composition of the protoplasm and killing the bacterium.²²⁷ The final explanation stated that disinfectants were able to kill germs by starving them of nutrients.²²⁸ These processes, whilst differing significantly in their mode of action, would all affect bacteria adversely. For many authors antiseptic action was therefore incomplete disinfection action, occurring where dilute solutions of disinfectants interfered with the activity of bacteria. It was a lesser effect or easier to achieve than disinfection. Nevertheless, other commentators disagreed, thinking that there was no necessary relationship between the antiseptic and disinfectant properties of a substance. The strongest supporter of this approach was Rideal, who believed it was better not to view the two groups of substances as similar.²²⁹ From his wider writing it

seemed that he was concerned about public confusion between antiseptics and disinfectants leading to ineffective disinfection; this once again demonstrates that antiseptics was implicitly approached as something lesser than disinfection by those concerned with disinfection.

Deodorants were also seen as having a particular action; acting on smells. Whether this was to be by destroying or masking the stench was unclear. Several authors focussed on the former, excluding the latter, and specifying that both could not be regarded as disinfection. For example E. Smith, writing in 1873, claimed that neither deodorisation nor masking bad smells was disinfection.²³⁰ Whilst Smith did not make clear what he considered deodorisation to be, other authors argued that it was the destruction of odours.²³¹ Such statements were common over the last three decades of the nineteenth century in all types of texts. Some authors also included masking smells within deodorisation.²³² This approach was, nevertheless, far less common, indicating that it was a lesser aim. Judging the relationship between deodorants and disinfectants was problematic. Many authors emphasised that deodorisation was not equal to disinfection, and that disinfectants were expected to do more than deal with smells.²³³ Others urged caution, pointing out that it could not be assumed that deodorants were necessarily disinfectants.²³⁴ These authors were willing to accept some exceptions to the rule but were cautious in giving any general advice. Few authors thought that disinfectants were necessarily able to deodorise, and any comments tended to concentrate on the properties of particular substances.²³⁵ Deodorisation was not equal to disinfection, and confusing them was dangerous. Both popular authors and professional advice texts frequently thought that the terms were confused, leading to ineffective disinfection.²³⁶ This was variously attributed to an aesthetic desire to remove offensive matter, or a delusion that the odours were the cause of disease.²³⁷ The situations in which antiseptics or deodorants were to be used therefore needed to be defined carefully and explicitly to avoid problems.²³⁸ The differences between disinfection, antiseptics and

deodorisation were more clearly delineated as the period progressed, and were thought to be of crucial importance in influencing effective practical disinfection. Definitions of disinfection were increasingly based on the exclusion of certain processes, and the implicit downgrading of their status in disease prevention. This emphasis on boundaries nevertheless indicates that the equation of disinfection with germicide was not as stable as disinfection commentators would have liked to think.²³⁹

The importance of disinfection as an intervention

As we have seen disinfection was increasingly defined in terms of its properties and older ideas were gradually excluded. Examining the change in attitudes over time can also illustrate its changing role in public health debates.

Some commentators were clear about the role of disinfection in public health and considered it very important. These statements, building on the increasing focus on disinfection in the 1860s, appeared in a number of texts of various types. Professional advice texts variously called disinfection “a therapeutic means of highest importance“, “valuable” and “imperative”.²⁴⁰ This enthusiasm for disinfection was reflected in popular texts. W. Stephenson, for instance, claimed that the domestic management of disease was crucial, and people needed to “wage war on infection within the house”.²⁴¹ Similar statements continued to appear over the next few decades indicating the importance placed upon disinfection by popular authors.²⁴² Others highlighted how the neglect of disinfection could bring disaster. One author claimed that disinfection had been greatly neglected, using the example of the outbreak of typhoid in the royal family as proof that even those with the money and access to disinfectants had not followed the necessary advice.²⁴³ As well as these specific comments, the increasing discussions of disinfection in manuals on disease prevention, popular health texts, medical journals and specific monographs demonstrates the growing importance placed on it. The LGB also paid increasing attention to disinfection, commissioning research on the comparative effectiveness of disinfectants and surveying the availability of disinfection apparatus in the localities.²⁴⁴ The range of situations in which disinfection needed to be deployed and the complexity and depth of advice also increased dramatically up to 1914. In summary

the visibility of disinfection on the public health landscape grew larger throughout the whole period. By 1900, there was consensus on the needs for disinfection of various types.

There is, however, bias in the sample of texts; they were chosen on the basis of containing information on disinfection so it is hardly surprising that the majority of professional and popular texts were positive about the concept. Nevertheless the positive approach of professional texts is supported by other examples; a survey of other texts shows that even in titles concentrating on specific diseases, processes and practices, disinfection was regarded as legitimate, even if the details were questioned. The visibility of disinfection in medical, public health and other professional journals also highlights that it was an increasingly accepted part of professional practice.²⁴⁵ The regularity of the appearance of disinfection in popular works was less clear. Their message on disinfection could be lukewarm, with several texts excluding or dismissing the subject, instead concentrating on the infection-preventing powers of cleanliness and ventilation.²⁴⁶ There are also hints of professional frustration by the end of the period with the way practical disinfection had deviated from professional advice.²⁴⁷ These issues are explored in greater detail in Chapter Five. Other texts showed fatigue with the rigours of disinfection. Discussion in the *Journal of the Sanitary Institute* in 1910 showed that some professionals were weary with the demands of disinfection: general practitioners had apparently discovered the problems of disinfection and were frustrated by the quack disinfectants advertised in the press and the credulity of the public who bought them.²⁴⁸ Professional critics of disinfection located the problems of method firmly in the public arena. Whether these structural difficulties could be overcome was unclear, and will be examined in later chapters. Disinfection could therefore be regarded as problematic. This was linked to concerns about the importance of other practices alongside, or in place of, disinfection.

Cleanliness and ventilation were variously regarded as a replacement for, a supplement to, or unrelated to disinfection. Most professional disinfection texts regarded the two as separate but important. A typical view of this type was that of Wynter Blyth.

He advocated not just passively resisting disease through cleanliness, but also waging war on microbes, via disinfection.²⁴⁹ Whilst both processes could thus aid disease prevention, disinfection was more active and decisive. There was, however, a strong line of dissent in other works which avoided or dismissed disinfection. Many texts which prioritised cleanliness over disinfection were concerned with the impact of filth in causing disease. N. Hartley, in his health pamphlet *Air, Water and Disinfectants*, discussed the role of cleanliness and ventilation in relation to disinfection. He claimed that it was known by all except the most obstinate and ill-educated that filth engendered illness, and many people thought that decaying matter was associated with the spread of disease.²⁵⁰ For this reason cleanliness was as important as disinfection in domestic disease prevention. Other popular texts over the next few decades continued to emphasise the role of cleanliness and purification, giving their audience a clear message about their relative importance.²⁵¹ Cleansing was a common injunction, and was considered important as a preventative and treatment agent for infectious disease without reference to disinfection. The independent incorporation of cleanliness and ventilation within disease-prevention nevertheless receded over time, with popular texts increasingly seeing these processes as working alongside disinfectants. As cheap, pleasant and safe popular disinfectants appeared on the market recommendations shifted. Other commentators, mostly medical men, went further, claiming that germs and disinfection had distracted attention from rectifying filthy conditions.²⁵² Chemical disinfection was a poor makeshift for cleanliness.²⁵³ The inclusion of this type of comment in some general texts and handbooks aimed at professionals is interesting and demonstrates that these critiques had a diverse base of support.²⁵⁴ It was, however, possible to consider both cleanliness and disinfection of equal importance. L. Weatherby, writing in the 1880s, provides a good example of someone who held both to be crucial. He thought that whilst disinfectants were “imperative” as a preventative measure, they were second best to free ventilation, and this should not be forgotten.²⁵⁵ He followed this up in a text published two years later, where he stated that, whilst disinfection was important in the management of

childhood infectious disease, cleanliness was also crucial.²⁵⁶ Other authors saw cleanliness as a way to approach uncertain disinfection. C. Cameron, writing in 1874, thought that whilst no disinfectant had been found to deal with cholera, cleanliness and other disinfectants would be an adequate substitute.²⁵⁷ Statements about cleanliness did not always exclude the importance of chemical disinfection but sought to deploy both in turn.

Medical support for cleanliness drew on alternative conceptions of disease prevention, and reflected older, pre-bacteriological processes.²⁵⁸ Cleanliness was seen as being of particular importance in “filth” diseases e.g. cholera. L. Beale, writing in 1885, claimed that cleanliness was sufficient to prevent cholera, and disinfection was unnecessary.²⁵⁹ This advice diverged sharply with ongoing bacteriological research and newer professional texts. This diversity can perhaps be summed up with reference to the work of R. Thorne. He was prominent in developing ideas about disease prevention and succeeded George Buchanan as principal medical officer to the LGB. He was also a keen supporter of the importance of cleanliness, seeing it as the crucial factor for preventing infectious disease.²⁶⁰ For example, in a book published in 1888 he discussed the decline of various diseases including smallpox, typhus and typhoid and ascribed their reductions to better housing, less filth, ventilation and other factors, rather than to disinfection.²⁶¹ Dirt itself was thus a disease-causing problem, making cleanliness a separate concern to disinfection, and one which had allegedly been more important in changing disease patterns.

Cleanliness was also redefined as disinfection itself. Authors also increasingly co-opted both light and air as disinfectants.²⁶² Light had initially been suggested as a germicidal agent from the mid 1860s, and proved to be one in 1877.²⁶³ It continued to be recommended throughout the period in professional texts as a means of disinfection.²⁶⁴ Research on light as a disinfectant made it clear that formally re-defining older, cleanliness-based processes as disinfectants was important in underlining the new science

of disinfection, and shifting public ideas about the action of common household processes. Ventilation could also be a “disinfectant”.²⁶⁵ Newman, writing in 1899, argued that the physical conditions affecting the growth of bacteria were important to disinfection: this included fresh air.²⁶⁶ These statements were, however, not confined to professional texts; popular publications also attempted to reshape ventilation as disinfection.²⁶⁷ These statements shaded into others about nature’s bounty in disinfection. Several popular works expressed the idea that nature had provided helpful, free and effective disinfectants: these were fresh air, water and heat.²⁶⁸ These statements, which appeared in both professional and popular texts, backed up the discussions of the individual properties of light and other “natural disinfectants”. Disinfection by cleanliness could then be seen as the most important method. E. Seaton emphasised the need to utilise nature’s disinfectants of light, air and soap and water in the fight against infection, and claimed these had been lost sight of in authorities’ rush towards other methods of disinfection.²⁶⁹ Seaton’s argument was similar to those put forward by people who substituted disinfection with cleanliness, the difference being that he had redefined the terms. Discussing light and ventilation as germicides thus changed the terms of the disinfection debate.

The incorporation of germs within cleanliness theory is also evident in discussions of dirt. Some authors thought that dirt acted principally as a medium for germs to thrive rather than a problem in itself.²⁷⁰ These sentiments continued to appear throughout the century in professional and popular disinfectant texts. Even Rideal claimed that dirty courts and alleys were the perfect culture medium for bacteria to develop, and that cleansing such areas was essential.²⁷¹ Germs could also be dirt. As the century progressed it was increasingly thought that infective dust was a problem for disinfection, particularly for tuberculosis.²⁷² The recognition of the germ-as-dust problem meant that processes that were initially regarded as cleaning could also be recognised as disinfection. The development of the vacuum cleaner in the early twentieth

century was therefore hailed as an innovative way to disinfect dust.²⁷³ Wet dusting was also advocated in professional and popular texts alongside processes of personal cleanliness and general hygiene.²⁷⁴ This emphasis on dirt within disinfection went some way to solving the problem that a disinfected room or object was not necessarily “clean”.²⁷⁵ Cleanliness and ventilation were therefore reborn as disinfection concepts, somewhat replacing their earlier independent status. Tomes has identified similar trends in the United States.²⁷⁶ Whilst definitions of disinfection had narrowed throughout the century to become focussed on germicide as the main legitimate action, if other processes which had previously been located outside disinfection, could be redefined as killing germs, then they would be brought within the fold.

Conclusion

Definitions of disinfection in the second half of the century thus concentrated on equating germicide and disinfection, excluding all other functions and branding them distracting or dangerous to “proper” disinfection. This theory became implicitly, if not always explicitly, exclusively concerned with bacteria, even in cases where no definite disease causing bacteria had been found. Alongside this, other disease-prevention practices were also defined and specified, so that antiseptics and deodorisation could be clearly delimited alongside disinfection. This strengthened the definitional status of all three processes, but implicitly imposed a hierarchy on them. Building on this, disinfection as germicide also grew in perceived importance in this period, with authors increasingly seeing it as a necessary part of any disease prevention campaign. In this way it seems that germ theory had brought new clarity to disinfection practice and had overhauled the entire subject, producing a clear, certain and exclusive category of action, based in scientific reason. This straightforward narrative nevertheless conceals some of the tensions and limitations associated with these changes. Disinfection as germicide was questioned throughout the second half of the century. Authors of both professional and popular texts continued to include other methods apart from killing germs within disinfection, giving a wider definition of disinfection practices, and, whilst these criticisms decreased in number and strength as time progressed, they highlight that

germicide was not necessarily the only conclusion that could be arrived at for disinfection in a germ era. Incorporating new germ ideas into the practical demands of disinfection could be problematic and varied according to the differing responsibilities of various parties. Exactly what was the focus for disinfection was also troubling, with gaps in the knowledge of disease-causing agents and disagreements about the resistance of those that were known making defining the parameters of “germicide” problematic. Finally, the ways in which germicide could be inclusive were also explored. A continued popular focus on cleanliness, rather than disinfection, was increasingly replaced with frameworks that saw cleanliness itself as germicide, and therefore as disinfection. New processes could thus be included within disinfection, provided they killed germs; while older ideas could be rehabilitated within a germ framework. These complexities were heightened when specific disinfection methods were considered, as the next chapter shows.

Chapter Three: Changing Ideas About Disinfection Practice 1840-1914

As we have seen in Chapter Two, disinfection theory changed rapidly in the second half of the nineteenth century. Alongside these developments, disinfectant methods and substances also began to change. The period after the 1870s saw the most rapid expansion and diversification in the agents available, and the methods recommended. Patterns and trends can be seen in changes to disinfectant practice, and these indicate how practical disinfection was regarded. This chapter covers changing approaches to disinfectant practice from 1860, examining particularly the ways in which practical advice was changed by the redefinition of disinfection as germicide and the new ways of testing disinfectants. Using three examples of practice this chapter shows that germ theory had varied consequences for disinfection advice. It had little effect on changing the general framework, and had ambiguous effects on fumigation. In heat disinfection, however, it overhauled advice and caused significant interest in the practical details. Whilst germ theory prompted some change there was no revolution in advice even from authors who regarded disinfection as germicide. This does not, however, mean that disinfection was, as Wohl has claimed, more like “science fiction” than good policy.

²⁷⁷ The measures could be drastic and far ranging, but were understandable in the

context of Victorian disease theory where practical experience still counted for as much as laboratory experience.

Frameworks of places and diseases

Translating the idea of germicide into recommendations could be problematic. As Chapter Two has shown, germicide could be drawn as widely or closely as was desired. Defining the purpose of disinfection was therefore an important part of translating theory into practice. This was done in several ways. At a basic level, the locations and diseases which needed to be treated were defined; these showed considerable continuity over time.

The first concern in disinfection was deciding on the target diseases. Whilst disinfection could potentially be applied to all diseases, practical and economical constraints demanded a more selective approach. Throughout the latter half of the century disinfection covered most, if not all, of the diseases defined as “zymotic”, and the core list was surprisingly stable across publications and time.²⁷⁸ “Zymotic”, derived from a Greek word meaning “to ferment”, was Farr’s development of Liebig’s chemical explanation of disease causation, and posited that many diseases were caused by “zymotic matters” that induced fermentation and disease in the body.²⁷⁹ Germ theory superseded this definition and rendered it irrelevant, but it seems that public health workers still found it helpful. Disinfection was therefore set firmly within a normal public health context, dealing with the same diseases as other policies. The main tenets of practical disinfection were not significantly changed by bacteriology; only the most specialist and detailed texts included descriptions of newly discovered bacteria and the diseases they caused.²⁸⁰

There were specific debates about whether to include new and pressing disease problems within disinfection. One area of concern was how to address diseases where the early symptoms were inconclusive. A good example of this is the debate over influenza. The so-called “Russian” influenza hit Britain in the winter of 1889, returning every year until 1893. The total death toll exceeded 125,000, making the disease an important health concern.²⁸¹ The use of disinfection was, however, debated on a number of points. The legal status of influenza disinfection was questioned. The 1890 Infectious Diseases Act

allowed influenza-infected items to be disinfected but, as influenza was not covered under the 1875 Public Health Act, patients could roam at will and spread the illness.²⁸² The applicability of the measure was also debated. The uncertain initial symptoms meant that measures like disinfection and isolation could not be applied in time to prevent influenza spreading.²⁸³ They could, however, still have some merit in specific cases, such as in hospitals or where there were few cases in an area.²⁸⁴ There was also no knowledge of which disinfectants, if any, would be effective against the unknown causal agent of influenza.²⁸⁵ Finally, the scale of the outbreak meant that costs of disinfection would also have been prohibitive.²⁸⁶ Disinfection for influenza was therefore unappealing; for practical reasons, germicide could not be applied to all diseases.

Some authorities nevertheless favoured disinfection. The House of Commons was controversially disinfected with carbolic acid and thiocamph, a pine-based disinfectant, in 1891.²⁸⁷ Parliament was eager to try any measure, however uncertain, to ensure that it did not succumb to the epidemic. The LGB also issued orders in 1892 for the disinfection and isolation of influenza along the same lines as other diseases.²⁸⁸ Practical experimentation was used even where the theory advised against it. These measures were, however, short lived and it is difficult to judge how far they were put into practice.²⁸⁹ Influenza disinfection did not appear as a concern in any of the case studies indicating that it was not a priority for these local authorities.²⁹⁰ The debates about influenza disinfection demonstrate the challenges that could be encountered when the specific disease approach came up against the realities of certain diseases. Similarly ambiguous early symptoms also led to the rejection of disinfection after episodes of measles and whooping cough.²⁹¹ This was in line with wider ideas about the inapplicability of public health measures, including isolation and notification, to measles.²⁹² Some diseases were increasingly regarded as fundamentally unsuitable for disinfection due to their clinical symptoms.

The complexity of applying disinfection to new diseases that did not follow the “zymotic” pattern can be further illustrated with reference to tuberculosis, arguably the most widespread infectious disease of the age.²⁹³ The discovery in 1882 that tuberculosis was infectious, whilst intensely controversial, caused significant changes in the way the disease was managed.²⁹⁴ As Koch himself pointed out, this new knowledge meant that prevention measures used for other diseases could be directed to the specific aetiology of tuberculosis.²⁹⁵ Disinfection was initially suggested as a treatment for active cases, with suggestions of this type appearing as early as 1888.²⁹⁶ Koch’s research also opened up new areas of investigation concerning preventative disinfection for tuberculosis.²⁹⁷ The advice developed in the 1880s and 1890s, as disinfection for the disease became increasingly important and advocated.²⁹⁸ Detailed codes of how to deal with the tuberculous sick room were produced.²⁹⁹ Management generally followed the same lines as for other diseases, albeit with far less urgency than in more acute diseases.³⁰⁰ Some modifications also had to be made. There were significant debates about when fumigation of the sick room should be done; given the lengthy nature of the illness patients had far more opportunity to infect different areas, necessitating repeated disinfection and fumigation as opposed to the single treatment recommended for other diseases.³⁰¹ This proved more expensive, more troublesome, and required significantly more supervision than other disinfection processes.³⁰² Some commentators therefore expressed doubt that fumigation could be applied to tuberculosis. Others showed that disinfection could be successfully applied if used at particular points in the illness.³⁰³ Disinfection also emerged as the main incentive in the notification campaign, with one author claiming that although notification could be problematic, it would allow disinfectants to be given out free and houses disinfected.³⁰⁴ This reveals the increasing importance of disinfection as a means of balancing the need to prevent the transmission of illness with the demands to continue everyday life; it is not surprising that

tuberculosis, with its long term and ambiguous development, shows this most clearly. The practicalities of diseases and their symptoms were thus a clearer influence over whether or not to disinfect than any strict bacteriological consideration.

The second concern in planning disinfection was which spaces should be treated. The spaces and places within which public health policies took place have been a key area of interest for historians.³⁰⁵ Disinfection was similar, and was closely associated with particular locations. Initially, it was concentrated on the patient and the sick room. This was based on the idea that the patient was the source of danger, exuding hundreds of minute infectious particles to contaminate the room and its contents. Given that the average patient would spend several days in the sick room, even if they died or were removed to hospital relatively swiftly, there was ample scope for contamination of the room.³⁰⁶ Statements about the importance of sick room disinfection appeared throughout the century in a range of publications, making it the most commonly advised location for disinfection.³⁰⁷ This could also have wider importance. Baldwin has shown how careful disinfection and sick room management was the means by which isolation policies could be moderated to allow the other members of the household to carry on some normal activities.³⁰⁸ Good practice could reduce the burden on the household. The details of disinfection were therefore important, and were frequently discussed. Management of the sick room was mentioned in all professional texts that gave practical advice, and was frequently the only location discussed in popular texts.³⁰⁹ This continued older practices and shows that new disease theories did not alter the main scope of disinfection.

Other locations which were regarded as extensions of the “sick room”, in that their danger came from the presence of the infected patient, were also of great interest. Ships were a particular concern throughout the period.³¹⁰ They were a place in which people had been residing, usually in crowded and imperfect sanitary conditions. If patients had been taken ill on board, ships were thus sick rooms with great potential for disease to spread. Ships also imported disease into the country via the ports. Ports were also a key concern for public health policy more generally.³¹¹ The disinfection of ships

therefore acquired a double importance as time progressed. Other transport locations were a concern. Cabs had been considered as potentially problematic from the 1866 Sanitary Act onwards, although they appeared relatively infrequently in advice texts.³¹² As options for travel became more varied and commonplace in the 1880s and 1890s, trams and trains were also added to the list of risky locations.³¹³ Patients who utilised public transport before their illness was recognised, or in contempt of restrictions, infected the cab or carriage in the same way that they contaminated a sick room. The disinfection of these locations appeared in specialist and professional texts, reflecting the fact that their management would fall to medical professionals rather than the public. Professional anxiety about transport does, however, also reflect wider concerns about the infectious dangers of everyday life.³¹⁴ Concern about these areas was not prompted by germ concerns, but can be traced back to earlier ideas about the patients as a source of danger wherever they spent their time.³¹⁵

New policies in both public health and social policy also added additional challenges for disinfection. The move towards notification and isolation from the 1880s directed attention to isolation hospitals and schools. The 1866 Sanitary Act allowed local authorities to supply specialist isolation hospitals, and several further acts added to the powers available.³¹⁶ The 1893 Isolation Hospitals Act then gave County Councils powers to compel local authorities to provide hospitals.³¹⁷ The bulk of isolation hospital construction dated, however, from the 1880s onwards.³¹⁸ Many local authorities undertook to build their own special hospital, separate from the workhouse infirmaries that had provided the most provision until then.³¹⁹ Increasingly large numbers of patients, mostly children, from a wide range of social classes, were treated in such institutions, although apathy and resistance continued in some areas.³²⁰ The specificity of care also increased. Isolation hospital nursing training started in 1885, aiming to undermine the notion that infectious disease nursing was a low-skilled job performed by pauper nurses.³²¹ Isolation hospitals thus provided a new environment for the

application of disinfection. The principles nevertheless remained the same as in home disinfection. Schools were increasingly a focus of concern from the late 1880s as compulsory schooling increased the potential for infection, and notification and concern for improving the health of schoolchildren highlighted this trend.³²² School disinfection was contentious, with debates over its merits and disadvantages continuing up to 1914.³²³ The verdict was often positive, but problems of cost and application could constrain its use.³²⁴ Other public spaces, including cinemas, theatres, churches and hairdressers, were also invoked as possible locations of infection.³²⁵ These concerns can be linked to increasing worries about asymptomatic carriers and those with concealed illnesses, such as tuberculosis.³²⁶ Education and disease prevention campaigns emphasised the possibility of more diffuse disease transmission routes and the hidden dangers in day-to-day interaction, heightening concerns.³²⁷ There was thus a broadening of the locations considered dangerous as time progressed; more public or semi-public areas were added to those initially invoked as problematic. This was influenced by the cultural impacts of germ theory and an increasing consciousness of the intricacies of disease prevention, but also owed much to the aforementioned concern about infected individuals as a source of danger. Germ theory was not the only factor prompting a widening of the locations of disinfection.

Disease control in practice: objects, diseases and methods

As we have seen, the sick room was the focus of most advice throughout the century. Structuring disinfection also required consideration of which objects would be treated, and why; most theories of disease causation indicated that some objects were more contaminated than others, and were thus more dangerous. The second half of the century saw two overlapping ways of understanding which objects needed to be disinfected, both of which remained in use and were largely unaffected by germ theory. This section examines the underlying principles of both of these approaches and highlights their development over time.

In the first instance, disinfection could be approached according to the nature of

the disease being treated.³²⁸ The best means of preventing diseases such as cholera and typhoid, which were spread by excreta, were thought to be disinfecting excreta and everything that had been in contact with it.³²⁹ This approach had been suggested in the 1860s, and continued to be recommended throughout the following decades in a wide range of texts.³³⁰ This shows that the focus on means of transmission was in place before the development of germ theory. The specifics of germ theory did, however, have an impact in widening the range of disinfection to include the excreta of asymptomatic typhoid carriers, and the urine of all sufferers as it was found to be contaminated with the bacillus.³³¹ Germ theory also reinforced existing ideas about other diseases. For exanthemata, diseases spread by the skin, the skin was the main focus.³³² This meant using lotions and baths to prevent germ-containing flakes of skin from escaping into the air.³³³ Other diseases, including diphtheria, measles, influenza, rubella, scarlet fever and whooping cough, were transmitted via the mouth and throat, and so prevention concentrated on these areas.³³⁴ Gargles and sprays were used to disinfect the throat and prevent bacteria spreading via the breath and mouth discharges.³³⁵ There had been some attempts earlier in the century to cure disease by using disinfectants to kill infection or germs within the body.³³⁶ This, however, proved ineffective and disappeared from disinfection literature by the 1880s. Discussions of bodily disinfection were increasingly concerned with the direct disinfection of the patient before infection could taint other objects, but this was not universally accepted and could not negate the need for other disinfection. Disease-specific ideas had been presented earlier in the century, but became stronger and more specifically grounded in particular research, demonstrating how germ theory had strengthened, rather than replaced, earlier ideas.

A second way to structure advice was according to which objects were likely to transmit infection. In most nineteenth-century approaches to disease causation the patient was seen as an ongoing source of large amounts of dangerous material. This changed little with germ theory, and identifying which objects were likely to be harbouring germs

became an important prerequisite for effective disinfection.³³⁷ Disinfection could be structured according to the patient's contact with the object. Items in close contact, such as clothes, were a particular danger, but more diffuse transmission could make walls, cutlery, or even visitors suspect.³³⁸ This approach appeared throughout the period in most professional and popular texts and was the most common way to present advice.

Objects were thought to transmit infection by means of fomites, a term used from at least the eighteenth century.³³⁹ Fomites were initially defined as "fine dusty infectious material that settled on and clung to clothes and other objects" from the sick room and similar areas.³⁴⁰ Germ theory added the concept that this dust was germs hidden in objects.³⁴¹ Fomites, strictly defined, were invisible particles that clung to objects, rendering them capable of transmitting infection over a lengthy period of time.³⁴² It was, however, colloquially used to mean infectious objects themselves.³⁴³ The principle illustrates how infection by objects was thought to operate. The range of objects which could act as fomites was wide. The patient's clothes and bedding, which were directly soiled with skin, discharges and excreta, were seen as intensely dangerous throughout the whole period.³⁴⁴ Utensils, crockery and other items used by the patient were also dangerous, as were the furniture and contents of the room.³⁴⁵ As time went on, however, other objects were added; these included library books and ships ballast.³⁴⁶ The ongoing belief in fomites and mediate transmission show how older ideas could easily be adapted to reflect germ theories.

There was, however, a countervailing tendency in some of the literature towards the end of the period with increasing questioning of the role of fomites in infection. Some hints that authors thought their role had been overplayed begin to emerge from the 1890s.³⁴⁷ New research published from 1905 onwards cast doubt upon the concept. Charles Chapin, a leading American MOH, claimed that disinfection of objects was not supported by any adequate evidence, was only helpful in particular cases, and could be safely

reduced without additional risk to health.³⁴⁸ Disinfection should instead concentrate on people as this was the main means of the spread of infection.³⁴⁹ This did not, however, discredit all disinfection of property: day-to-day cleanliness remained important, and disinfection was important for spore-bearing bacteria.³⁵⁰ Thorough disinfection was still necessary to contain outbreaks of new diseases in an area.³⁵¹ Fomites were therefore still relevant in exceptional circumstances, and their role was undermined, although not discarded.³⁵²

The reaction to the work is interesting. It “fell like a bombshell” in America, and few agreed with it.³⁵³ English reactions were less critical. A positive review appeared in *Public Health* in 1910, stating that “the book deserves the careful study of all who are working for the prevention of infectious disease”.³⁵⁴ Although the work was not reviewed elsewhere it is clear that, at least for *Public Health*, the prospect of reducing the scope of disinfection without sacrificing disease prevention was appealing.³⁵⁵ Unsurprisingly, heroic disinfection was not attractive if less taxing policies would achieve the same ends, showing that conservative approaches to fomites and disinfection were concerned with efficacy rather than blind adherence to older practices. Whilst fomites had been adapted to germs, by 1910 germs were finally changing belief in fomites. The timing of this shift is contrary to existing historiographical views. J. Raymond has claimed that by the 1890s, bacteriological science increasingly rejected the idea that germs could survive outside the human body for any length of time, undermining a focus on the environment and disease.³⁵⁶ This was not reflected in discussions about disinfection, and we should reconsider the extent to which environmental germs were regarded as non-dangerous in the period after 1890.

In this way, the effects of germ theory on ideas about objects and disinfection came much later than other estimates suppose, and were limited in extent. They were also not significantly influenced by new bacteriological research.³⁵⁷ This contrasts strongly with the current historiography, which has tended to focus on the ways in which public

health shifted away from an “inclusive” policy, looking at places and their healthiness, towards an “exclusive” focus on infected people.³⁵⁸ Worboys has located this move earlier in the century, before 1880, and argued against it being a result of germ theory.³⁵⁹ As the discussion of fomites shows, disinfection complicates this picture. The trend towards “exclusivity” was not straightforwardly reflected in practical disinfection, and this highlights that there was significant continuity as well as change in thinking about disease and the role of the environment in its causation. This is a significant finding and shows that any understanding of public health policy in this period must recognize the continued diversity of approach. It also reveals the problems of dividing the two categories; whilst disinfection was “exclusive” in that it was directed on the basis of identifying infected persons, and treating their surroundings, this focus on the environment also aligned the policy with older approaches.

In this way the main tenets of disinfection remained similar across the period. This can best be illustrated with reference to two specific advice texts, from 1866 and 1903.³⁶⁰ They agreed that disinfection was important, and that the patient and the sickroom were the focus of the work. They both advocated disinfecting clothes, bedding and excreta by heat and chemicals, the isolation of the patient, and the disinfection of the room at the end of the illness. In this way, overall continuity was maintained, demonstrating the extent to which germ theory only touched the extremities, rather than the heart, of disinfection.

Change and continuity in chemical disinfection

As we have seen, overall advice remained stable. Bacteriological research was, however, able to undermine the perceived effectiveness of particular chemical agents, and unseat the accepted hierarchy. This section examines the effects of germ theory on chemical disinfection and fumigation, highlighting that its impact was complex and varied according to a number of practical factors.

As outlined in Chapter Two, chemical disinfection was widely practiced in the first half of the century. It continued after 1860, with disinfectants being an integral part of sickroom practice, and, increasingly, commercial products became integrated into a more general cleaning regime. The significance of chemical disinfectants and the public

response to them is outlined in Chapters Four and Five. The sheer range of recommended agents also multiplied rapidly, whilst the core advice in favour of carbolic acid, chloride of lime and some commercial disinfectants remained stable from 1870 onwards. Choosing a disinfectant nevertheless became increasingly difficult as the market became more crowded.³⁶¹ Whilst new research provided information about the hierarchy of effective disinfectants this did not translate easily into advice, as the following case studies show.

Carbolic acid, also known as phenol, was possibly the most prominent chemical disinfectant of the age, and shows the extent to which a disinfectant could withstand the fundamental undermining of its effectiveness.³⁶² Carbolic was the most commonly recommended disinfectant in texts throughout the period.³⁶³ It was, however, the subject of significant criticism from the 1870s onwards. Concern had preceded the development of germ theory, but was significantly bolstered by experiments which showed that the chemical performed poorly in killing various types of micro-organisms.³⁶⁴ As bacteriology grew in strength so did the undermining of carbolic. Many authors, both popular and professional, pointed to the lack of effectiveness of the chemical, variously denying that it was a germicide, stating that it was comparatively ineffective, and that it could not kill spores.³⁶⁵ Whilst criticism mellowed after 1900 in some texts, even authors such as Rideal, who thought it a weak germicide, advised that it was not an effective practical disinfectant.³⁶⁶ New research offered ways to test carbolic, and it was often found lacking.

Popular recommendations for carbolic, however, continued.³⁶⁷ For some, this was based on a lack of engagement with new research. Many popular texts made no mention of the problems associated with the substance.³⁶⁸ Others claimed that despite other research findings, carbolic was practically effective in halting and killing germs.³⁶⁹ For others, its popularity and other advantages were enough to outweigh its lacklustre germicidal powers.³⁷⁰ Many authorities chose carbolic because it was cheap and readily

available.³⁷¹ It was also very popular with the public.³⁷² The discontinuity between medical and popular advice is clear. The ambivalent effects of germ research and concepts also emerge: a lack of germicidal effectiveness, and cautions about its use, were not enough to unseat professional and popular affection for carbolic.

Conversely some agents which had not been generally used in the early part of the century became widely recommended in certain types of texts due to their impressive germicidal efficacy. Perhaps the best example of the impact of bacteriological research on the chemicals recommended for disinfection can be seen in corrosive sublimate (mercury chloride).³⁷³ The chemical had occasionally been used earlier in the century, but was not one of the key recommended disinfectants.³⁷⁴ The advent of bacteriological techniques, however, highlighted that it was particularly effective in killing germs and spores; this made it a very attractive choice for stubborn diseases or those with an unknown causal agent.³⁷⁵ This germicidal research prompted an increasing number of recommendations in advice texts. Many medical and some popular authors included it within their approved lists, and Notter and Firth identified it among the most commonly recommended disinfectants.³⁷⁶ Authors throughout the 1880s, 1890s and 1900s, both professional and public, agreed that it was the best germicide available.³⁷⁷ Clearly, high germicidal abilities made a substance attractive.

There were, however, problems, as expert and specialist texts demonstrated. It was increasingly recognised that corrosive sublimate was ineffective in the presence of organic matter, as they formed an inert compound, and was unable to effectively act on the germs.³⁷⁸ Several approaches were suggested to overcome this problem, such as the addition of an excess of the chemical, or of acids, but these did not completely solve matters.³⁷⁹ The substance also attacked metals making it difficult to store and handle. There were also serious safety issues caused by the preparation; these are explored in greater detail in Chapter Six. Finally, the association of mercury compounds with the treatment of syphilis could have deterred people although this was not frequently

mentioned as a limiting factor by contemporaries.³⁸⁰ These drawbacks go some way to explaining why corrosive sublimate did not oust the arguably more ineffective carbolic acid as the most popular and widely recommended disinfectant.³⁸¹ Despite its vaunted efficacy and recommendations for popular disinfection, this did not result in its widespread use. As with carbolic this indicates that germicidal concerns were insufficient to bring it to new prominence. These two case studies also show the divergence between professional and popular advice; unsurprisingly, professional advice kept closely to methods based on bacteriological research, whereas popular authors were more conservative, even where they accepted the validity of germ theory. This gulf between types of advice could be problematic, as Chapter Five shows.

Fumigation: how germs undermined methods of disinfection

Germ theory also had an impact on other areas of disinfection. As well as ongoing disinfection of the objects while the patient was recovering, the room needed to be disinfected at the end of the illness in order to prevent reoccurrence of the infection. Most commentators agreed that the best way to disinfect thoroughly a sick room was fumigation, and references to fumigation appeared in all texts throughout the century.³⁸² Germ theory nevertheless had a significant impact in changing ideas about the effectiveness of different fumigation agents and the processes associated with it.

Before the 1890s, fumigation advice concentrated on sulphur and chlorine.³⁸³ The germicidal effectiveness of both substances was, however, increasingly questioned throughout the latter half of the nineteenth century. Sulphur came in for the most criticism, and the backlash began from the 1870s.³⁸⁴ For example, in 1871, J. Dougall claimed it was “very ineffective as a germicide”.³⁸⁵ These statements continued throughout the following decades, appearing for the main part in specialist disinfectant texts, but also in medical journals and other works.³⁸⁶ The substance was so poorly regarded that by 1900 *The Lancet* claimed that sulphur fumigation was “little better than a rite or an incantation”.³⁸⁷ The specific conditions needed to make sulphur effective

were also outlined in increasing detail.³⁸⁸ The chemical was found to be ineffective on particular species of bacteria and in dry environments.³⁸⁹ It also had poor power to penetrate items, meaning that it could be relied upon only for superficial disinfection.³⁹⁰ Some authors explicitly linked this questioning of sulphur to the emerging bacteriological research explored in Chapter Seven.³⁹¹ From this we can see that germ theory and research was having a significant effect in undermining traditional methods of disinfection, and older practices were not immune to scrutiny from new scientific methods.

There is, however, another side to the story. Some were unconvinced that sulphur was ineffective, pointing to positive, practical experimental results which demonstrated its efficacy.³⁹² More importantly, sulphur remained the agent most generally recommended by popular advice texts until 1910.³⁹³ It was often accepted that this was the method that would be used by local authorities to disinfect houses, and it was recommended by medical professionals and the British Government.³⁹⁴ Indeed, *The Medical Times and Gazette* in 1882 thought that the belief in sulphurous acid was “so well rooted in the minds of the profession as well as the popular mind that it seemed almost a pity to disturb it”.³⁹⁵

How did these authors square their recommendation with the emerging research on germicidal inefficiency? Some claimed it was a result of simple inertia.³⁹⁶ Ignorance or lack of concern was also implicated. In some cases, especially in the popular texts, there was little mention of the new research.³⁹⁷ Whilst these authors generally accepted disinfection as germicide they did not engage with bacteriological research and continued to recommend methods based on their traditional practical efficacy. Medical texts took a different tack, and acknowledged the research but pointed to other factors supporting the effectiveness of fumigation. For instance J. Gay claimed that sulphur was not necessarily effective, but that the level of care it demanded inculcated due attention that was positive

for disinfection.³⁹⁸ Others pointed to the whole “package” of sulphur and associated processes as the important factor, claiming that evidence showed that these processes were disinfectant themselves and finished an otherwise incomplete chemical process.³⁹⁹ It was the familiarity with the process, not sulphur itself, that was important in ensuring success. Sulphur could thus be rendered germicidal once more by strict attention to detail. These debates demonstrate the differences between the preoccupations of theory and practice, and the extent to which even well-accepted research did not revolutionise advice. Similar developments can be seen in chlorine which, despite generally more promising initial results, did not increase in either recommendation or use.⁴⁰⁰

The ambiguities of the choice of disinfectant agent can be explored most notably with reference to formaldehyde. The development of formaldehyde as a disinfectant illustrates the impact of new chemical inventions on disinfection, and the extent to which bacteriological knowledge had changed how disinfectants were judged. Formalin initially came to popular attention in the mid-1890s, and was heavily debated by commentators in journals, books and newspapers so that by 1898, considerable data existed on it.⁴⁰¹ Indeed, *The British Medical Journal* claimed no other disinfectant had been through the same scrutiny of its effectiveness and characteristics.⁴⁰² Formalin could be used in two ways: as a liquid disinfectant, and as a fumigating agent.⁴⁰³ Few new fumigating agents had been suggested by the 1890s, and commentators were eager to see new, “scientific” principles put into practice. Several commentators were very much in favour of the chemical.⁴⁰⁴ Andrewes claimed that it had opened up a new era in aerial disinfection, and that it was a far better germicide than either sulphur or chlorine.⁴⁰⁵ Similar statements appeared in medical texts and some popular manuals, demonstrating widespread confidence in formaldehyde’s powers.⁴⁰⁶ Bacteriological research was therefore informing the advice given by disinfection specialists.

Initial optimism gave way to concern, with many commentators claiming that formaldehyde was not as efficient as had been suggested.⁴⁰⁷ It was subjected to rigorous

testing, and many of the debates about effectiveness hinged as much on the validity of the methods of testing as on the substance. An exchange of letters in 1897 debated the choice of test organism, whether liquid or gas had been used, the method used to produce the gas, and other factors.⁴⁰⁸ For some, this rigour was reassuring, but for others it was confusing and unhelpful.⁴⁰⁹ The contested nature of formalin highlights the extent to which newer methods were rigorously tested, whilst older techniques were less susceptible to critical scrutiny. As the amount of evidence grew it became apparent that many disagreements over its effectiveness as a gaseous disinfectant could be explained by the poor powers of the chemical in practice.⁴¹⁰ Despite several attempts to overcome these problems, they could not easily be solved and this limited the purposes the gas could be used for.⁴¹¹ Initial enthusiasm, therefore, descended into concerns and infighting about the exact properties of the substance and how far the germicidal effects were curtailed by its practical limitations. Formalin was thus not the start of the “new era in fumigation” that Andrewes had predicted, but did provide a significant advance.

The debates about formaldehyde highlight some important changing aspects of disinfection research in the latter half of the century. New methods of testing, although imperfect and lacking consensus, nevertheless ensured that new disinfectants were rigorously scrutinised. The huge outpouring of ink on formaldehyde, its germicidal properties, and its drawbacks as identified in the laboratory and in practice demonstrate the new hurdles that disinfectants had to navigate before they were accepted. Some contemporary authors saw this as a positive move which would sharpen and enhance practice. A. K. Chalmers, a Scottish MOH, claimed that “the whole fabric of disinfection depends on bacteriology”, and “bacteriology alone determined which [substances] are ranked among the germicides.”⁴¹² Others, however, claimed that bacteriology had thrown such doubt on the efficacy of so-called disinfectants that the implicit confidence of the past seemed likely to be succeeded by hopeless scepticism.⁴¹³ These comments hint at fears that this would undermine the entire concept of disinfection. Whilst neither of these extreme scenarios occurred, the fragmentation of disinfection advice was regarded as a key cause of confusion and ineffective practice. The effects of germ theory

were thus a double-edged sword.

Innovation and germs: replacing fumigation

The increasing concerns with the effectiveness of specific fumigation chemicals were paralleled by a more general concern about fumigation as a method. This was perhaps the most significant challenge to any aspect of the disinfection process, but had mixed effects. As disinfection theory turned from looking at aerial miasmas to specific germs, fumigation was increasingly considered problematic. In the first half of the century fumigation was seen as a process whereby the air itself could be disinfected. As time progressed this notion was increasingly rejected. There were hints at this from the 1870s onwards. For example, in 1874, Hart claimed that the air could only be defiled, not purified, by chemical treatment, and that such disinfection was a costly, clumsy and irrational way to disinfect germs on furniture and walls.⁴¹⁴ This was, however, an isolated statement, and most commentators, both popular and professional, were reasonably happy with the concept of fumigation. By the 1890s, however, research increasingly demonstrated that the germs targeted by fumigation were located on the surfaces of the room rather than in the air itself.⁴¹⁵ Fumigation was therefore a long-winded way of applying chemicals to these surfaces, relying on the associated post-processes for its apparent efficacy, and was pointless.⁴¹⁶ Criticism in professional and medical texts intensified after 1900, although this was not universal.⁴¹⁷ These statements did not appear in popular texts, demonstrating the gap between professional and popular advice as well as theory. The concern about surfaces also left space for more direct methods to be substituted, as the next section shows.⁴¹⁸

One way to deal with these concerns was to come up with innovative new methods that delivered chemicals directly to infected surfaces, namely spraying. This was the most interesting innovation in methods of application in the period, and offered the possibility of a “modern” approach to disinfection. The process had initially been developed in France but grew in international popularity and was advocated in Britain from the late 1890s onwards, so that by 1900 it was a common section in disinfection texts.⁴¹⁹ The process was discussed in detail by many commentators who were anxious

to ascertain the effectiveness and applications of the method.⁴²⁰ Spraying used a jet of disinfectant fluid from a pressurised apparatus to coat walls, floors, furniture and other hard surfaces and thus act directly on the germs.⁴²¹ It was heralded as superior to fumigation, which, as we have seen, was increasingly regarded as inefficient.⁴²² Spraying was able to deal with large areas, such as rooms, rapidly and efficiently.⁴²³ It was not, however, without practical problems. Covering the whole area to be disinfected was a concern. Many authors called for apparatus to be able to produce a fine and even spray to allow good coverage of surfaces and to avoid any areas being missed.⁴²⁴ This also conveniently meant that there would be minimal wastage of the disinfectant, reducing costs.⁴²⁵ The flexibility of the method also added to its appeal; any disinfectant fluid could be utilised in the equipment, meaning that the new germicidal star products could be utilised and varied according to the resistance of the disease.⁴²⁶ The conditions required for efficiency thus generally moved in the same direction as those needed for practicality. There was, however, also a clearer skill premium than for fumigation: spraying needed to be undertaken with care to be effective and practical.⁴²⁷ This could be problematic for authorities who employed unskilled, slapdash workers.

Balancing these competing positive and negative features led to significant differences of opinion. The germicidal drawbacks of the method meant that some professional medical authors remained sceptical about its usefulness.⁴²⁸ Some, however, were able to overcome their concern. Notter and Firth were initially sceptical, but by 1900 included a much enhanced section on the practice, and highlighted its existing strong support.⁴²⁹ The practical advantages also meant that the method had allegedly become popular by 1902.⁴³⁰ Despite certain drawbacks, it offered a plausible alternative to fumigation, and was taken up by some authorities. Thus, a combination of germ ideas and practical expertise had led to the development of a new alternative to fumigation, showing the extent to which germ theory could provoke new ideas. Nevertheless,

fumigation remained a popular form of disinfection in Britain, even when other countries, such as America, France and Germany had abandoned it.⁴³¹ Spraying therefore highlights that Britain was significantly more conservative than other countries and may well have taken a very different approach regarding disinfection.⁴³² This is interesting in light of the more practically minded character of bacteriology in Britain.⁴³³ Despite the alternatives there was significant inertia in practical methods as well as advice, as the next chapter illustrates.

Another approach to the questioning of fumigation based on laboratory research was to examine existing practices and identify which parts were effective. This meant a concentration on the importance of pre- and post- fumigation processes, including stripping walls, limewashing, washing with disinfectant solution and scrubbing floors: all had the potential to kill or displace germs. The addition of these processes to the whole disinfection package became more common as the century progressed and demonstrate the increasing concern with the efficacy of disinfection. Pre-fumigation processes were generally aimed at allowing better access to infectious matter.⁴³⁴ This played on concerns about the lack of penetrating power of chemicals, and emphasised the need to bring the substance into direct contact with unprotected germs. The processes recommended after fumigation were consistent across different types of texts. Wallpaper was to be stripped to ensure no germs were hiding in it.⁴³⁵ Some texts recommended that it was then burnt to ensure all infection had been destroyed.⁴³⁶ Afterwards, the walls and furniture should be washed with disinfectant soap, and the walls re-papered or whitewashed.⁴³⁷ Whitewashing over old paper was a source of “needless danger”.⁴³⁸ Ceilings were generally to be whitewashed, and floors were to be scrubbed with disinfectant solutions.⁴³⁹ Finally, allowing air and sunlight in the room was recommended as a way to clear out the hazardous fumigating agent but also to reinforce the disinfection of the room.⁴⁴⁰

Post-fumigation processes were far more commonly discussed and recommended

than pre-fumigation, and their importance was emphasised by many professional and popular authors.⁴⁴¹ The importance of these processes overshadowed gaseous fumigation itself in some cases. Dr. F. Vacher claimed that the post-fumigation processes were the really important ones as they actually killed the germs, but they were often neglected as it was assumed that they were less needed due to fumigation.⁴⁴² Such processes were recommended in many popular texts, demonstrating that although their authors were less convinced by new research they were still concerned that gaseous fumigation alone was not effective enough to guarantee success.⁴⁴³ Modifying existing practices, and re-emphasising the relative value of various parts of the process was therefore an appealing response to the germicidal doubt about fumigation. Concern about the laboratory-demonstrated ineffectiveness of sulphur and chlorine led to a range of responses which referenced and used germ concepts in varying ways to develop new solutions to disinfection problems. Nevertheless, whilst germ knowledge was able to change disinfection advice this did not proceed in a straightforward way; new methods were constrained by practicalities which limited the extent to which the most effective solutions were recommended.

Disinfecting Objects: germicidal effectiveness, practicality and the effects of germ theory

As we have seen, the basic requirements of disinfection remained largely accepted across the period, whilst adjustments and changes were made to practice in chemical disinfection and fumigation. The field most significantly affected by changes in theory was heat disinfection. Heat had been suggested as a disinfectant in the earlier half of the century.⁴⁴⁴ Nevertheless, the real growth in its use can be located in the latter half of the century, as authorities increasingly adopted apparatus to heat treat textiles and other objects. Heat could be applied in a variety of forms, and choosing between them was difficult. This was nevertheless one of the key areas where germ ideas combined with practical motives to prompt significant changes in practice over time.

The simplest heat disinfection method was boiling. This had been recommended in the first half of the century as an effective way to cleanse items, and was seen as a means of killing even the most resistant germs from the 1870s onwards.⁴⁴⁵ There was,

however, recognition of the limitations of the method. John Tyndall had found that boiling a substance once did not kill all the germs it contained.⁴⁴⁶ Repeated boilings were needed to disinfect items.⁴⁴⁷ The mood, however, remained mostly positive, and this was reflected in continuing recommendations in professional and popular advice texts throughout the period. Texts recommended boiling for all washable textiles, to follow soaking in a chemical disinfectant, or as an appropriate method of itself.⁴⁴⁸ Other household items benefited from this treatment, for instance utensils and cutlery.⁴⁴⁹ These statements appeared in a wide variety of texts but were more common in popular texts that advised on home disinfection. Boiling therefore remained a recommended domestic disinfection process throughout the later nineteenth century.

There was, however, increasing recognition from the 1870s onwards that boiling needed to be undertaken carefully in order to be effective.⁴⁵⁰ Items such as bulky textiles, bedding and mattresses were also proved by research to be more difficult to deal with by boiling, as the method did not always allow full, thorough disinfection of the item. On a more pragmatic note, boiling could only be applied to small batches of items, making it ineffective for widespread or prolonged outbreaks of disease. As authorities were increasingly responsible for disinfecting large volumes of clothing they needed a more suitable method. Locating responsibility for disinfection with private households was also problematic as there was no quality control.⁴⁵¹ Some commentators therefore recommended that municipal disinfection, which used baking and steam, should be the preferred method as this would ensure a uniformly effective process.⁴⁵² Professional texts, and indeed significant numbers of home advice texts, increasingly focussed mostly on steam disinfection.⁴⁵³ Recommendations that boiling be replaced with municipal disinfection, however, preceded the real impact of germ research in some cases.⁴⁵⁴ The switch from boiling to other types of heat advice was therefore not entirely based on its germicidal effectiveness, although it was influenced by concerns to kill all germs.

With boiling problematic other methods were recommended. The first one to gain

attention was hot air disinfection. This had initially come to widespread attention in the 1840s, but then revived as an item of debate by the 1870s. After initial concern about the lack of knowledge of the method's effects on germs, research proliferated and was positive about dry heat. In 1875, Dr. Baxter, working for the LGB, undertook a series of experiments on the degree of heat needed to destroy the infectivity of vaccine lymph, and concluded that dry heat was an effective disinfectant.⁴⁵⁵ Confidence was so high that some commentators placed hot air above moist heat.⁴⁵⁶ This confidence was reflected in recommendations, which continued to appear up to the 1890s.⁴⁵⁷ There was, however, increasing recognition of the method's drawbacks. Some of these were of a practical nature. As gases are poor heat conductors, ensuring a constant temperature throughout the apparatus, and ensuring that the temperature could be effectively measured and controlled, was a major concern for hot air apparatus.⁴⁵⁸ Hot air also penetrated objects very slowly, meaning that items needed to be treated for long periods of time.⁴⁵⁹ This length of exposure frequently caused damage, meaning that items such as mattresses were often significantly damaged on the outside, but still not disinfected on the inside.⁴⁶⁰ The temperature at which hot air disinfection needed to be undertaken was much discussed: it needed to be high enough to ensure efficacy, but low enough to avoid damaging articles.⁴⁶¹ This compromise was difficult to achieve and there was significant debate about how to balance the different needs.⁴⁶² It was also thought that disinfection workers would skimp on the length of time in the apparatus, avoiding damage to the items and confrontation with angry members of the public.⁴⁶³ In this way, the characteristics of dry heat disinfection were often problematic in practice.

More worryingly, the efficacy of hot air was also increasingly questioned. Research by various authors, starting with Koch and Wolffhugel, gradually showed it was relatively ineffective even within the confines of the laboratory.⁴⁶⁴ Parsons and Klein, in research undertaken in 1884 on behalf of the LGB, also found that it was ineffective, and

moist air was no better.⁴⁶⁵ Hot air thus proved to be ineffective on most items, although it continued to be used in particular contexts, such as laboratories, in surgery, and for items that could not be steamed.⁴⁶⁶ As research increasingly undermined confidence in the effectiveness of hot air, it became less likely that texts would advise it; the recommendations lingered longest in popular works.⁴⁶⁷ Most authors approached it as a last resort, to be used only on particular difficult-to-disinfect items such as leather, or if other methods were unavailable.⁴⁶⁸ It was clearly regarded by many as a less effective and more difficult alternative to steam disinfection.⁴⁶⁹ The dubious germicidal efficacy of hot air, along with its practical problems, meant that it was discredited, and gradually fell out of widespread use. This demonstrates the ways in which germ ideas could overhaul practice.

With the increasing discrediting of hot air disinfection, other methods, in particular steam disinfection, were recommended. Steam disinfection had previously been mentioned alongside dry heat, and indeed some types of dry heat apparatus could be or were adapted to be used with bowls of water in the chamber.⁴⁷⁰ Steam was, however, increasingly recommended and researched as a method itself from the 1880s onwards.⁴⁷¹ Once again Koch and Wolffhugel were important in promoting the effectiveness of steam in research undertaken in 1881.⁴⁷² Koch, although not the first to recommend the method, was a persuasive and high profile supporter of it. Various researchers found steam killed even the most resistant bacteria such as anthrax and its spores.⁴⁷³ They also investigated the way in which steam penetrated items, and found it better at disinfecting items all the way through.⁴⁷⁴ By the mid-1880s, therefore, there was significant research consensus on steam as the best means of disinfection.⁴⁷⁵

The research had an impact on disinfection advice. The method became far more commonly recommended in the 1880s so that by 1889 it was the accepted way to treat textiles.⁴⁷⁶ The dominance of steam in the professional literature was not always

reflected in the popular texts, with some continuing to advocate baking, boiling or chemical disinfection alongside steam.⁴⁷⁷ There were some overall practical problems with its use which limited its applicability: these are explored in more detail in Chapter Five.⁴⁷⁸ This, combined with a conservative approach to methods, served to limit interest in steam in some quarters. For example, Parkes' *Manual of Hygiene* was conservative about it, recommending hot air alongside steam throughout the 1880s.⁴⁷⁹ Notter and Firth, building on the earlier Parkes text, were rather more positive about hot air disinfection than any other writers even as late as 1896.⁴⁸⁰ In this way, although there was a significant consensus on steam as the best means of disinfecting textiles by the late 1880s, there was still inertia in some sectors about designating it as the only useful method. Nevertheless, the germicidal efficacy of steam, as proved by "modern" laboratory-based research made it the usual method of choice.

Whilst steam rapidly became the preferred method of disinfection, the specifics of its application were not agreed on as quickly. One of the main controversies was whether steam should be superheated or saturated.⁴⁸¹ Saturated steam was a term referring to steam heated to the boiling point of water for the given atmospheric pressure (the boiling point of water is higher at higher pressures).⁴⁸² This steam condensed on the surfaces of items in the disinfection chamber, releasing its latent heat and disinfecting the part of the item it condensed on.⁴⁸³ In condensing, it also shrank in volume, pulling other steam into the vacuum it left and starting the pattern once more, slightly further into the item.⁴⁸⁴ This meant that saturated steam had considerable powers of penetration and could be relied on to disinfect the interior as well as the exterior of even reasonably bulky items such as mattresses.⁴⁸⁵ Superheated steam, on the other hand, was steam heated above the boiling point for the atmospheric pressure, meaning it acted like a gas.⁴⁸⁶ Superheated steam was found not to condense on items in the same way as saturated steam, as its temperature was so much above boiling point and unless it was brought down or the

pressure increased, the steam would not condense.⁴⁸⁷ This meant that items were less readily penetrated and thus were liable not be correctly disinfected on the inside.⁴⁸⁸ Superheated steam could therefore be used at higher temperatures, theoretically giving better disinfection, but saturated steam had properties that meant it was more effective.

There was initially little distinction made between the merits of the different types of steam.⁴⁸⁹ Increasing focus on the specifics of steam disinfection from the 1880s, however, brought this issue to prominence. There were several attempts in this decade to demarcate clearly the difference between the two types of steam.⁴⁹⁰ These debates tended to appear in specialist advice texts rather than in popular texts. Householders could not undertake steam disinfection so home texts did not concern themselves with the intricacies of how steam should be applied. Moist steam, i.e. saturated steam, was increasingly deemed to be much more effective than dry heat in killing bacteria.⁴⁹¹ There was, however, some dissent in the medical press about the effectiveness of steam, with several authors claiming that the differences between the types were less pronounced in practice than in theory.⁴⁹² Superheated steam also had some practical advantages. It could aid the drying of objects in the disinfecting chamber, stopping items from being damaged, and returning them in the same condition in which they were put in the chamber.⁴⁹³ Despite these advantages, saturated steam came to be regarded as superior due to its greater germicidal powers.⁴⁹⁴ The debates demonstrate the ways in which the specifics of steam disinfection increasingly came to the fore once the overall method had been agreed upon. They also show that where there was consensus on the germicidal effectiveness of a method, minor disadvantages could easily be navigated.

On the other hand discussions about the pressure at which steam disinfection should operate also show how practical considerations could constrain change. High pressure was often regarded as more effective.⁴⁹⁵ At higher atmospheric pressures, steam condenses at higher temperatures, meaning the effects of saturated steam could be had at higher temperatures which were better at killing bacteria.⁴⁹⁶ Pressure also helped

increase penetration into items and shortened the disinfection time.⁴⁹⁷ These practical factors were all important for the high volumes of items local authorities were expected to disinfect, and even where the increased germicidal effects of high pressure steam were disputed commentators recognised the practical benefit.⁴⁹⁸ There were also drawbacks. Higher pressures necessitated heavier equipment which was unstable and more likely to explode; the equipment also required specialist management from its operators, which could increase labour costs.⁴⁹⁹ With high pressure apparatus more expensive to install and maintain, despite being more effective its practical drawbacks made it less appealing.
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Authors attempted to demarcate the limits of practical necessity versus absolute disinfection. Controversy erupted in the late 1890s between S. Delepine, an advocate of low-pressure, and several others who championed high pressure.⁵⁰¹ The debate hinged on whether Delepine's research was sufficiently reliable, and had left enough leeway to account for variation in disinfection effectiveness.⁵⁰² The issue lapsed into an uneasy compromise by the late 1890s, with high pressure apparatus recommended for larger areas and towns, whereas smaller and rural areas could get away with low-pressure apparatus.⁵⁰³ The issue was evidently only dormant, however, and the debate reignited in 1905 with a series of articles in several journals.⁵⁰⁴ In this case, the type of research was the key to the issue. J. Thresh, who favoured low pressures, disagreed that laboratory testing was a good basis for judging the effectiveness of steam disinfection.⁵⁰⁵ Instead, he believed that it should be based solely on experience.⁵⁰⁶ On the other side of the debate high pressure advocates rejected Thresh's practical tests as inconclusive.⁵⁰⁷ The importance of contested evidence is clear in these debates, and shows the problems of using research to inform practice. The arguments also reveal that the authors fundamentally disagreed on what a disinfectant should do. Delepine and Thresh both claimed it should operate at the lowest operating specifications that were able to kill

normal infectious disease germs, and argued that since authorities would not encounter spore-bearing diseases they had no need for heavy duty apparatus.⁵⁰⁸ Other commentators expected authorities to disinfect to the safest standard known. With no end to the debate in sight *The Lancet* eventually “ruled” on the issue, claiming that high pressure saturated steam was more certain, but that streaming steam a few degrees above the condensation point was adequate for most practical disinfection purposes.⁵⁰⁹ By 1909, it was therefore accepted that low-pressure apparatus could deal with most diseases, damaged goods less, was simpler, lighter and cheaper to make, and was portable.⁵¹⁰ Nevertheless, low pressure was also acknowledged as less reliable than medium or higher pressure.⁵¹¹ This debate illustrates some interesting points about heat disinfection more generally. The increasing focus on the exact specifics of steam disinfection is clear here, demonstrating how new knowledge and ideas about disinfection led to more detailed debates about practice and greater specification of particulars. Whilst generalised methods had sufficed in the first half of the century, detailed scientific research demanded particular actions, making disinfection more complicated. What also emerges is an interesting preoccupation on the one hand with absolute disinfection, and on the other with the idea of doing “enough”. The importance of practicality in these debates is also clear; where practical factors such as cost, difficulty of application and professional authority moved in the same direction as bacteriology, the transition between methods could be relatively simple. Heat disinfection therefore provides the best example of how germ theory was able to exert significant and lasting changes over advice, whilst also showing the extent to which practical factors were also of great importance. It was far more difficult to draw the boundaries of practical advice than simply to state that disinfection was germicide.

Conclusion

The advent of germ theory led to a significant change in how disinfection was conceptualised and to increasing reliance on bacteriological methods as the main way of testing the effectiveness of disinfectants. This, however, had relatively little effect on the practice of disinfection. The core locations, diseases and objects that provided the

framework for disinfection remained mostly the same as time progressed; practical considerations were of as much influence as germ theory in adding new aspects to disinfection. By the end of the period there is evidence of some stirring towards change, as germ theory started to undermine, rather than promote, the “heroic” approach to disinfection. This had taken several decades from the acceptance of germ theory, demonstrating that the effects of new ideas should not solely be measured in the short term. In terms of specific methods germ theory also had a limited and ambiguous impact. Methods that were effective germicides were increasingly recommended, and those which were judged to be ineffective faced criticism; these shifts were not, however, definitive. Whilst professional texts drifted away from recommending some of the less “effective” chemical substances, popular texts continued to recommend them. A similar pattern can be seen in the development of fumigation advice. Old methods retained purchase long after their ability to kill germs was questioned, whilst new methods were subjected to lengthy and exacting testing processes before they were even partially accepted. In this way, whilst germ theory was able to unsettle the perceived hierarchy of effective measures it did not have the capacity to cause sudden and revolutionary change. There were, however, areas in which germ theory had a significant and obvious effect relatively early on. Changes in heat disinfection were shaped by changing ideas about the effectiveness of methods in killing germs, showing that germ theory could have an early influence. This reflected the fact that there were fewer embedded ideas about heat disinfection, and that the practicalities ran in the same direction as effectiveness. These were strong influences on the timing of change, demonstrating the overall importance of practical problems in shaping the reception of ideas about methods. Disinfection might have been germicide, but this was significantly tempered by other factors and there was no clear pattern visible in the primary sources of germ theory universally prompting any specific and sudden changes in disinfection practice.

Chapter Four: Disinfection at local level

Chapters Two and Three have examined how ideas about disinfection changed between 1800 and 1914. Disinfection advice was also evolving significantly in this period. Alongside developments in theory, disinfection practice changed substantially too, with newer disinfectants coming to the fore as older preparations were increasingly

criticised. It was not necessarily the case that theory and practice developed at the same rate. To some extent this might be expected as new theories usually took some time to be put into practice. Disinfection at local level did not undergo changes at the same pace as the advice literature, and there were significant delays in adjustments in practice. This chapter thematically investigates local disinfection practice in five case study areas within Lancashire, in the context of the literature already explored, and the county more generally. A range of primary sources was consulted for Manchester, Liverpool, Preston, St. Helens and Bolton. These included MOH reports, council minutes and the local press. They show that local authorities were undertaking disinfection, and it was a respected part of their public health programmes. The methods used remained fairly stable over time, with newer practices permeating only slowly, despite the widespread acceptance of new ideas such as germ theory. In this way, the discontinuities identified in Chapter Three become even clearer.

The case study areas: a note

It will be helpful to give some background about the towns, and sanitary policy in each of the five case study areas. All of them are situated within the historical county of Lancashire. According to Platt, Lancashire had a unique urban hierarchy, with “a large network of highly integrated upland satellite cities orbiting the metropolis” of Manchester.⁵¹² Tracing the development in policy in this region is therefore especially interesting and illuminating. The towns chosen represent urban areas of differing size, occupational structure, politics, policy and topography, broadening the scope of the investigation. For short details about the characteristics of the different towns, see Appendix One.

Disinfection and legislation: the framework for local action

It is important to understand the changing national and local legal powers local authorities possessed. Public health legislation grew greatly in the later nineteenth century.⁵¹³ These laws covered matters from the provision of water and gas supplies, housing, notification of infectious disease, and other matters.⁵¹⁴ These powers came from both national and local acts, leading to a patchwork of varying provision.⁵¹⁵

Hamlin has argued that national legislation was relatively unimportant in the development of many sanitary features, with local areas continuing to seek their own acts.⁵¹⁶ Disinfection did not fit this pattern, as local acts usually did not include provisions for disinfection; unusually, general legislation gave authorities the abilities they required.⁵¹⁷ The same powers were available to all the case studies if they chose to use them. National legislation increasingly included disinfection powers, reflecting the growing interest in allowing local authorities to undertake disinfection. Whilst legislation before the 1860s had allowed disinfection of certain types of premises there was no allowance for wider measures.⁵¹⁸ This changed over the second half of the century. From the mid-1860s, as Hardy has shown, cattle plague and cholera prompted more generalised powers for infection control.⁵¹⁹ The “clumsily workable” 1866 Sanitary Act was a key step forward in controlling disease, and was the first measure significant for generalised disinfection.⁵²⁰ If a certificate issued by a medical practitioner said that “cleansing or disinfecting of any house or part thereof, or any article therein liable to retain infection, would tend to prevent or check infectious or contagious disease”, the nuisance authority had to give notice in writing requiring the owner or occupier to cleanse and disinfect. If they failed to comply within the time specified they were fined up to 10 shillings for every day of default.⁵²¹ The authority could also disinfect the property themselves and claim the costs back from the owner.⁵²² Where the owner was unable to carry out the work properly the authority could do so without recovering costs.⁵²³ In this way, the feckless and the poor were treated the same, potentially causing offence to both. There were also other penalties. If any person knowingly let an infected dwelling without having it disinfected to the satisfaction of a qualified medical practitioner as testified by certificate, they were liable to a penalty not exceeding £20.⁵²⁴ Clauses for the disinfection of objects also appeared. A fine of up to £5 could be imposed on anyone who “gave, lent, transmitted or exposed any bedding, clothes, rags or other things exposed to infection without previous disinfection”.⁵²⁵ The only exclusion was if

the objects were being taken to be disinfected. The local nuisance authority was allowed to provide a “proper place” for the disinfection of infected textiles, and authorities could disinfect free of charge if they wished.⁵²⁶ The 1866 Act therefore set up the foundations of the system of disinfection described in Chapter Three.⁵²⁷

The next act which extended disinfection powers was the 1875 Public Health Act. This has been seen as a milestone, as it consolidated the “great mass” of health law, unified the powers available to local authorities, and implemented a number of important reforms.⁵²⁸ The Act made some subtle and significant alterations to disinfection. Authorities continued to be allowed to disinfect houses, provide apparatus to disinfect objects, and perform other actions.⁵²⁹ There was, however, a shift in emphasis. The Act added that the MOH could provide the certificate that would compel owners to cleanse, disinfect or whitewash houses.⁵³⁰ The addition of the role of the MOH, a post made obligatory by the 1872 Public Health Act, in determining which premises were to be disinfected was of crucial importance in the move from private to public control of disinfection. The Act also made the exemption of poor householders from costs more explicit, and added new powers which were arguably aimed at protecting and ensuring compliance from the poorer classes. The Act allowed compensation to be paid. The previous lack of compensation for damaged or destroyed goods had been a powerful incentive for poor families to evade the measures. Finally, the role of central government in directing specific disinfectant policy was set out. The LGB could make regulations, including for disinfection, to prevent the spread of disease.⁵³¹ The Board was thus able to make efforts to shape the specific practices of disinfection without needing further legislation to do so.

This move towards local authority control was strengthened in the 1890 Infectious Diseases Prevention Act.⁵³² If authorities adopted the act, their powers for disinfection were enhanced and they were accorded more responsibility.⁵³³ The balance of power was thus decisively shifted away from the householder and towards authorities. Authorities were to notify owners in writing of the need to disinfect premises. If there

was no reply within 24 hours agreeing to do it to a satisfactory standard within a specified timescale, the authority could disinfect the house themselves and charge the owner for the process.⁵³⁴ Similar clauses applied for moveable property. The Act also allowed the authority to give notice to the owner of any article that had been exposed to infection to submit the objects for disinfection; they were to be disinfected and returned free of charge.⁵³⁵ If any “unnecessary” damage was caused then the authority was obliged, rather than empowered, to compensate the owner.⁵³⁶ These sections removed the rights of householders to act independently but also reduced the work and expense, and offered compensation for damage. This shows an increasingly professionally-empowered approach to disinfection, tempered with recognition that this needed public assent.

This more authoritarian approach was also reflected in the provisions for visits to private premises. Any appointed officer had power of entry between 10am and 6pm to carry out the provisions of the Act.⁵³⁷ This had not previously been included, and shows an interesting commitment to public health above the sensibilities of property owners. These hours were extended to 6am to 9pm in 1907.⁵³⁸ The Act also lightened the load for working and middle-class families. The local authority was newly empowered to provide, free of charge, temporary accommodation for families displaced during fumigation.⁵³⁹ This was aimed mostly at the poorer classes living in single room accommodation. Other sections of the Act, however, imposed penalties specifically on tenants if they failed to disinfect or made false statements.⁵⁴⁰ In this way, owners were protected against tenants’ poor conduct. Where the clauses on renting were in force, however, the authority was to give notice to the occupants of any house where they knew there was a case of infectious disease.⁵⁴¹ This also gave some protection to tenants as they would receive the information they needed.

The provisions of the act were novel in many ways. Unlike earlier legislation it threw most responsibility on the local authority, and implied that disinfection as undertaken by the public was potentially suspect. This put an increased burden on the authority, and allegedly led to authorities changing their policies in order to reduce this,

such as by reducing the duration of fumigation to avoid having to house families displaced by the process.⁵⁴² The Act also seemed to set the precedent that disinfection should be free of charge for all using the service.⁵⁴³ Further legislation added additional powers to offer on-request disinfection for those with vermin-infected clothing, and to disinfect laundry and books.⁵⁴⁴ These did not, however, alter the overall structure. The development of legislation shows that power was increasingly vested with local authorities rather than the public. This recognised the increasingly specific and scientific underpinnings of disinfection, and suspicion of the ability of the public to undertake it effectively. In this way, legislation became more, not less, authoritarian, in contrast to developments in other areas of policy, such as vaccination.⁵⁴⁵ The continuing focus on environments, not people, is also clear. This is contrary to ideas about the increasing “exclusivity” of policy, whereby it concentrated on controlling infected people, revealing the difference between disinfection and other policies.⁵⁴⁶

Notification and Isolation: stamping out disease.

As we have seen, legislation established powers of disinfection. Nevertheless, without knowledge of which houses were harbouring disease disinfection would be incomplete. The issue of compulsory notification was therefore extremely important in determining how disinfection was practiced.⁵⁴⁷ Notification was the means by which information about premises to be disinfected was obtained. Indeed, some commentators agreed that notification was an essential precursor to disinfection, and it was not worth pursuing disinfection unless notification was in place.⁵⁴⁸ This was what Hardy has termed “stamping out”. The system developed in the wake of the rinderpest outbreak of 1866, but was quickly recognised as having, with some modification, potential applications to controlling smallpox.⁵⁴⁹ The solution that developed relied on neo-quarantinist policies of isolation of cases, and the rigorous disinfection of houses and possessions of the stricken.⁵⁵⁰ Another consequence was notification acts, which started out as individual local acts from the 1870s onwards.⁵⁵¹ They mandated that wherever

cases of listed diseases were identified, the medical practitioner in attendance, or the householder, was required to send a certificate to the local authority, which would then take action to prevent the disease spreading.⁵⁵² This was unpopular with the medical community, and caused significant debate.⁵⁵³ The measures were nevertheless so popular with those in power that legislation was passed in 1889 allowing any authority to adopt notification.⁵⁵⁴ In 1899 notification became compulsory throughout the country.⁵⁵⁵ National disinfection policy was therefore based on something approaching reliable evidence only after 1899.

The chronology of notification differed between the case study areas. It is clear that almost all of them were undertaking some informal process of information gathering before notification acts were passed.⁵⁵⁶ They then passed specific notification measures. Bolton was the first town in England to implement a general notification measure, passing a local Act in 1877.⁵⁵⁷ The main impetus for this came from the enthusiastic local MOH, Dr. Sergeant, who thought it necessary to prevent disease.⁵⁵⁸ The policy was not, however, publicised until after the local act had been passed, and once its significance regarding liabilities for medical practitioners became obvious there was serious discontent from the local practitioners.⁵⁵⁹ They mounted an ultimately unsuccessful campaign to modify or repeal the legislation over the next ten years.⁵⁶⁰ Other areas had similar problems. Liverpool attempted to pass a notification bill several times between 1881 and 1883, but early information provoked organised medical opposition, successfully blocking it.⁵⁶¹ Whilst a strong medical profession could be beneficial for some policies, it also hindered reforms which were perceived as detrimental to doctors.

Liverpool eventually succeeded in gaining a measure after the 1889 national act.⁵⁶² St. Helens also adopted compulsory notification under the 1889 Act, having made no previous attempt to pass a measure.⁵⁶³ The national act allowed areas to override opposition, and prompted others to undertake the policy where they had previously not

shown interest.⁵⁶⁴ Manchester council also had problems when it tried to pass a notification measure in 1882. Some medical professionals opposed the measure, and drew on support from their colleagues in Liverpool.⁵⁶⁵ They failed to stop it being passed, and opposition allegedly died down afterwards. Conversely, for some authorities passing the measure was relatively easy. Preston put forward a bill for notification of disease in 1880, which was passed in 1881.⁵⁶⁶ The Council claimed that the bill had faced no opposition and that all interested parties had been informed, but admitted that there had been no publicity surrounding it.⁵⁶⁷ It may have slipped through without too much attention, preventing organised opposition. Notification therefore followed different trajectories in the different towns, indicating that in some areas no comprehensive disinfection policy could be pursued until relatively late in the century.

The third aspect of ‘stamping out’ was isolation. Isolation powers were granted by the 1866 Sanitary Act and updated by subsequent legislation.⁵⁶⁸ It was increasingly hoped that notified cases would be isolated, either within their own homes, or preferably, in special hospitals.⁵⁶⁹ Keeping the patient within a small space limited the spread of germs, and meant that the disease was less likely to break out in other locations. It also had the benefit of limiting the area that needed to be disinfected, and, if precautions were followed as described in Chapter Three, would also reduce the number of objects to be disinfected. Indeed Porter (née Watkins) has claimed that, for notification to be effective, isolation accommodation was essential.⁵⁷⁰ As time progressed, there was increasing focus on the need for isolation to take place in specially designed hospitals. Mooney has argued that these institutions, whilst making routine the physical separation of infection encountered in other isolation practices, also acted to change citizens’ hygiene and domestic practices in a wider sense.⁵⁷¹ Compulsory isolation could be unpopular, raising resentment from the working classes for a number of reasons. They perceived the implication that their nursing care was inadequate, were afraid that their relatives would not receive good care, and resented hospital policies that limited their ability to visit their

relatives.⁵⁷² Willingness to co-operate with isolation varied over time and according to the severity of the disease; smallpox in particular promoted compliance.⁵⁷³ Isolation therefore became an increasingly common experience. Specialist isolation accommodation also added a new consideration in the disinfection of items. Patients who were admitted to hospital would have their clothes disinfected there rather than at the local authority's facility, shifting the workload between different parts of the health system.⁵⁷⁴

With this in mind, let us examine the development of isolation in the case study areas. Each of them has its own history regarding provision and, as Mooney has shown, the rules of different institutions in relation to practices such as visiting could vary greatly.⁵⁷⁵ There is insufficient space to describe the development of isolation hospitals in each case study in depth; instead, this section identifies the key points relevant to disinfection. The first important point is that isolation accommodation was slow to develop, and was contentious.⁵⁷⁶ Indeed, most towns did not have specific isolation hospitals for several years after implementing notification policies, despite the emphasis that several MOsH put on the "stamping out" system.⁵⁷⁷ The construction of hospitals was problematic due to the financial burdens it raised and also to public concerns about the infection risk from facilities located near housing.⁵⁷⁸ In many of the localities studied, Preston in particular, it was found that, despite years of pressure, campaigning and the construction and extension of various institutions, provision lagged behind the needs of the populations.⁵⁷⁹ This was typical of the speed of development across the country generally. Wohl has shown that by 1891 only 400 provincial sanitary authorities had constructed isolation facilities, due to the high costs.⁵⁸⁰

Given this lack of specialist accommodation, several of the areas continued to use a range of institutions to provide care. In Liverpool the council maintained accommodation in a private fee-paying hospital, used the workhouse for some cases, and then constructed its own hospitals from the 1880s onwards.⁵⁸¹ The pattern was repeated

among the other authorities studied.⁵⁸² This patchwork of provision continued even after the construction of purpose-built hospitals, demonstrating the extent to which isolation was a pressured and fragile system which could be overwhelmed if a conjunction of different epidemics occurred together.⁵⁸³ There was some improvement over time, with most areas seeing increases in the percentage of notified cases which were isolated, due to improving isolation facilities, decreasing disease levels and greater willingness to accept hospital care.⁵⁸⁴ The second important point is the involvement of other local bodies in policy. Local Poor Law Guardians usually provided isolation facilities for paupers, and workhouses were often used throughout the period for isolation of the general working-class population where no hospital was available or the existing one was over-full.⁵⁸⁵ This reflects the extent to which local health structures were intertwined with the poor law.⁵⁸⁶ The use of workhouses for infectious cases would have pauperised those families before the 1885 Medical Disqualification Removal Act. Mooney has claimed that the presence of paupers in isolation institutions was off-putting to the better-off, and the fear of pauperisation was a direct deterrent in London for those families who might have used the institutions. This assumed that only paupers were put into London workhouse hospitals. On the other hand, evidence from the case studies shows that, in at least some instances, officials considered putting non-paupers into a workhouse, with the attendant legal problems this caused. Whether they would have admitted this policy publicly is unclear, but it adds another interesting dimension to the context of the 1885 Act. Given the poor reputation of workhouse infirmaries this is likely to have been problematic for the public.⁵⁸⁷ It also brought the local authority into conflict with the poor law. This added another level of variation, meaning once again that disinfection should be viewed in the context of an imperfect attempt to implement stamping out.

As we will see in Chapter Five, professionals were anxious about the public's role in disinfection, and wanted to be the foremost authority in disinfection. The development of legislation demonstrates this tension, as it removed autonomy and power from individual householders and relocated it with the local state. In the case of both isolation and disinfection this had a basis in efforts to improve the effectiveness of policies, but

was also linked to concerns about authority and ability to undertake procedures to a professional standard. These tensions formed the backdrop to the implementation of local policy.

Disinfection policies in the case study areas

So, how did local policy develop? As we have seen, local powers for disinfection of objects were introduced in 1866. The public health acts also mandated that authorities undertook disinfection of items, houses and general disinfection advice. Identifying how local authorities responded to these changes is important. This section therefore examines the development of general disinfection policy in the case study areas.

The timing of the developments is crucial. Lucinda Beier has claimed that disinfection was applied to an increasing range of ailments “beginning in the 1880s”.⁵⁸⁸ F. B. Smith has also made similar statements, stating that disinfection became “even more terrible” after “new fumigation techniques were developed in the 1880s”.⁵⁸⁹ On the contrary, the local areas show that disinfection was being undertaken before 1866, and that this varied between the five localities. Epidemic sickness was a prompt to disinfection in a number of areas. In Preston in 1832, with the approach of cholera threatening the town, several means of prevention including whitewashing, disinfection and street washing were considered.⁵⁹⁰ In Bolton, limewashing and purification were mentioned in relation to epidemics, specifically cholera. Liverpool also disinfected houses after cholera.⁵⁹¹ Non-epidemic disinfection was less common, but existed in some areas including Bolton, Manchester and Liverpool.⁵⁹² Policies relating to particular properties and groups, such as lodging houses, were also highlighted in Preston, Manchester and Liverpool.⁵⁹³ Only one case study, St. Helens, showed no evidence of disinfection.⁵⁹⁴ It seems that the smaller towns with less developed structures may not have had the capacity to pursue these policies. The disinfection of houses and dwellings was therefore well established in most of the towns studied by the 1860s, emphasising the overall continuity with the later period.

The 1866 Act widened disinfection in the case study areas. Much of this work was

undertaken by the local Boards of Guardians; they were the driving force for disinfection in Preston and Manchester.⁵⁹⁵ The councils also undertook disinfection. In 1867, the Manchester City Council instituted a system of cleansing and disinfection.⁵⁹⁶ This intensification of activity after 1866 is in keeping with Hardy's finding for London, where authorities utilised their new powers to cleanse premises.⁵⁹⁷ The 1871 smallpox outbreak was also a significant motivator, prompting action in all five towns.⁵⁹⁸ Defining the boundary between varying jurisdictions was problematic, especially during epidemics, and there were disputes in several areas about the role of Poor Law Guardians.⁵⁹⁹ In Preston, the Guardians accused the Corporation of neglecting its duties to cleanse and disinfect houses.⁶⁰⁰ In Bolton, a dispute arose between the Guardians and the Sanitary Committee over a case of fever that had resulted in a workhouse nurse catching typhus. The Guardians claimed that Mr. Kay, the nuisance officer, had refused to whitewash and cleanse the house.⁶⁰¹ He denied all allegations. These disputes over who was legally responsible for disinfection, and the alleged failings of the local authorities, show how co-operation was fragile. Disinfection was taking place before the policies of public health authorities became routine, although this was more limited in scale than later in the century and could be confounded in practice because of lack of clarity over local responsibilities. Disinfection was emphatically not adopted solely as a result of germ theory, but was a pre-existing practice in many urban locations.

Routine, systematic disinfection became far more common by the 1870s. Most towns did not keep detailed records of practice year-on-year, and expositions of day-to-day work appeared only occasionally. This is less of a problem given the continuity in many areas. Most of the case studies had established a common pattern of disinfection by 1874, including fumigating houses, disinfecting items, distributing disinfectants and advice, and specialist policies such as the disinfection of dead bodies.⁶⁰² These characteristics of disinfection were remarkably stable over the last three decades of the nineteenth century.⁶⁰³ The appointment of MOsH in the medium sized and smaller

towns seems to have been a key influence in the more organised and widespread nature of the practice. Indeed, in St. Helens, the smallest and institutionally least-developed case study, action only really started after 1874 when Dr. Robert McNicoll was appointed MOH.⁶⁰⁴ He set about establishing the usual system of disinfection, showing how far it had become standard by that time. The overall approach to disinfection was thus set in the 1870s, demonstrating that the advent of organised public health allowed an expansion of existing disinfection programmes into routine practices, but not any absolute innovation.

Disinfection systems at local level: diseases and places

As we have seen, disinfection systems intensified in the 1870s and the details merit investigation. Decisions needed to be made about the diseases to be disinfected. In general these matched those covered in advice texts. All the case study towns undertook measures for disinfection and fumigation of typhoid, typhus, smallpox, scarlet fever, diphtheria and cholera as standard.⁶⁰⁵ This list matched those “zymotic” diseases which were of concern more generally.⁶⁰⁶ Where resources were limited, isolation was often prioritised to the most serious and tenacious diseases, and special care taken over their disinfection; especially smallpox and scarlet fever.⁶⁰⁷ It was the perceived tendency of certain diseases to spread more easily that influenced how they were approached. Decisions on whether to disinfect the “marginal” diseases were also taken. As discussed in Chapter Three, there was debate over whether diseases such as measles should be disinfected. There are several instances in the case studies where this was undertaken.⁶⁰⁸ On the other hand, there were other occasions on which disinfection of this type was explicitly rejected as being too expensive, inefficient or simply not needed.⁶⁰⁹ Measles therefore emerges as an aspect of disinfection which reflected the discussions in medical literature particularly well and shows that the practical factors identified in the literature were correct.

New diseases were also added to the list: for example, Liverpool, as a major port, developed policies to deal with plague.⁶¹⁰ Ideas about the infectivity of tuberculosis

were growing from the 1880s after the discovery of the tuberculosis bacillus in 1882.⁶¹¹ Hardy has shown that active prevention of phthisis dated back to the 1890s and could include disinfection.⁶¹² Disinfection for tuberculosis appears in some of the case studies in the early 1890s. In Bolton the issue was raised after one medical practitioner had voluntarily applied for the house of a tuberculosis patient to be disinfected. This was welcomed by the authority, who formulated a specific disinfection policy for the disease.⁶¹³ Liverpool, Manchester, St. Helens and Preston undertook similar voluntary disinfection programmes, from 1897 in the case of Liverpool, and 1899 onwards in the other examples.⁶¹⁴ When notification, either voluntary or compulsory, was put in place in these towns their disinfection programmes expanded.⁶¹⁵ Indeed, disinfection was often seen as a key reason for enforcing notification.⁶¹⁶ This could be problematic. There was some uncertainty as to whether compulsory disinfection could be applied to tuberculosis under the existing laws: most authorities got round this by seeking their own powers, usually alongside measures for compulsory notification.⁶¹⁷ Disinfection for tuberculosis was more socially sensitive, and necessitated more accommodations with the public, but was generally accepted by 1900. This reflected the intersection of new knowledge and practical concerns, and shows one area in which new discoveries had a direct influence over policy.

The types of location disinfected also expanded over time. Municipal disinfection usually concentrated on homes and the objects removed from them, occasionally disinfecting public spaces as necessary. The advent of compulsory education also meant that schools were an increasingly important location for the spread of disease from the 1880s onwards.⁶¹⁸ Local authorities applied their disease prevention policies, including disinfection, to schools and developed methods such as school closure.⁶¹⁹ There is also evidence of efforts to inform other locations including libraries and washhouses about infectious diseases.⁶²⁰ Some areas also found they needed to disinfect public places due to irresponsible patients. In Preston in 1903, a hawker infected with smallpox “took the

opportunity of decamping from the [isolation] hospital” and although the authorities were able to track him down within three hours, he had visited a number of public houses and a barber’s shop, all of which needed to be disinfected.⁶²¹ Necessity therefore extended the range of locations that could be disinfected. Local authorities also frequently embarked on environmental disinfection. In Preston, smallpox provided the impetus for a strict disinfection programme, including the disinfection of alleys, streets and yards.⁶²² Disinfectants were also distributed as a general environmental improvement measure. In 1896, Dr. Pilkington claimed that disinfectants were given out to any person who wanted to use them on an ashpit, yard or about their premises.⁶²³ He thought that whitewash in particular disinfected, but also improved the look of properties and acted as an impetus to further improvements in cleanliness.⁶²⁴ Disinfectants, whilst conceptualised as anti-germ agents, could be more generally used as purifiers, revealing the practical elision between these aims. This shows the ways in which disinfection could shade into other preventative measures such as environmental cleansing. This continued up to the end of the century; clearly the idea of disinfection as specific targeted germicide, although known and acknowledged by local MOsH, did not undermine the continuation of older, environmental approaches. This is in direct contrast with the idea that public health policy increasingly focussed on infected people, not places.

In any location activities regarding disinfection fall into three main categories; distribution of disinfectants, disinfection of houses and disinfection of items. Involving the public in disinfection was a key concern in all five locations. Chapter Five explores the role of the public more closely, and shows the extent to which professional debate acknowledged the need for the public to be involved in disinfection. Public reactions to public health policies more generally have been a subject of close scrutiny. Brunton points out that sanitary reform was one of the key ways in which the state interfered in the lives of private citizens in the nineteenth century.⁶²⁵ Several authors have emphasised the role of resistance in shaping working-class reactions to public health measures.⁶²⁶ The importance of outrage and class sensibilities in middle-class responses

is also crucial.⁶²⁷ Indeed, several historians have argued that the wealthier sections of the population were not made subject to policies unless there was a clear cause, such as a specific complaint that there was a problem with that particular household.⁶²⁸ It is important to consider which sections of the population were subject to disinfection.

As we have seen, legislation initially allowed for householders to take on disinfection themselves; this made it easier to avoid doing the work thoroughly. There is evidence that householders undertook their own disinfection and there could be significant demand for popular disinfectants.⁶²⁹ We would, therefore, expect the case studies to show evidence of amateur disinfection. It is evident that not all cases of disinfection in these towns came under public authority. In Manchester disinfection for tuberculosis was usually left to the householder unless the house was “dirty” or the sufferer unwilling to heed advice.⁶³⁰ Routine disease disinfection could also be undertaken by the public. In Preston, for instance, the MOH commented on the discrepancy between the number of bundles of bedding disinfected and the cases of disease, attributing it to the home disinfection or destruction of children’s bedding, as this was easier and appropriate.⁶³¹ Fumigation, however, was “little more than a farce, and does harm by inspiring confidence” when done by unskilled hands. Some processes should not, and increasingly were not, done by the public. By 1897 Mr. Pilkington claimed that the number of houses fumigated actually exceeded the certificated cases of zymotic disease, due to the disinfection of houses infected with measles.⁶³² Manchester also specifically pointed to an increase in the number of houses disinfected by the authority in 1887.⁶³³ By 1895, most infected houses were disinfected by the local authority, at its expense.⁶³⁴ This demonstrated the expected pattern, whereby increasingly wide sections of the population were brought within disinfection. Preston, alongside Manchester and St. Helens, had also adopted the 1890s Infectious Diseases Act, giving them wider powers to compel disinfection.⁶³⁵

This seems to have been part of a longer-term move towards more widespread

disinfection. Disinfection statistics have survived for all the towns.⁶³⁶ The annual figures show significant fluctuation due to varying levels of infectious disease, making them difficult to interpret.⁶³⁷ To add to this, whilst population levels were increasing in most of the case study areas in this period the rates of infectious diseases were dropping. We can, however, get some indication of trends over time. All but one of the five localities show an increase in the number of rooms disinfected, and similar patterns for the number of items disinfected, although the chronology differs. In St. Helens there was a general increase over time, with much of the increase occurring from the late 1880s and early 1890s onwards. Bolton also showed an increase in premises and items treated over time, with the main increase occurring in the mid 1880s. Liverpool saw increases up to 1900, then a dramatic increase. Preston saw an increase up to 1900 and then a fall, followed by an increase up to 1914. The evidence points to the fact that disinfection was reaching an increasing proportion of the population, including those further up the social scale. Indeed, there is some limited comment about public co-operation. In 1888, the Manchester MOH claimed that he found that medical men and householders were usually willing to co-operate with notification, isolation and disinfection.⁶³⁸ Whilst this may have been overconfident, it highlights that the interests of the public and the authority did not necessarily run counter to each other. This accords well with Romano's viewpoint that by the end of the century obstacles to the implementation of health policies across the social order had decreased.⁶³⁹ This was due to scientific knowledge over-riding privacy, and was linked to new ideas about professional identity.⁶⁴⁰ It can also be seen to owe much to increasingly specific fears about germs, and combating them. In this way, the social consensus behind disinfection made it grudgingly acceptable even for middle-class residents, showing that the study of less contentious policies can be revealing. This is in line with other literature which shows that policies could be accepted, complied with and seen as useful.⁶⁴¹ This links to the idea that public and private interests did not always conflict; the authority could implement policies that were acceptable to citizens.⁶⁴² The public's reactions to a particular policy could vary, and each policy demands

individual investigation.

There were times when local authorities deferred to popular preoccupations. Wohl has claimed that authorities encouraged “do it yourself” disinfection, as it removed the problems of avoidance of authority disinfection.⁶⁴³ There is evidence of authorities allowing this. In Liverpool, householders were allowed to strip wallpaper and whitewash walls after fumigation, but this caused problems, as owners were reluctant and the work was often delayed. The health committee therefore concluded that the only way to get the work done was to get the sanitary staff to do it. Owners and occupiers were to be absolved of any responsibility, bar repapering, in cases of premises rented at less than £30 per annum; the authority even undertook to notify owners when repapering could commence. St. Helens were also suspicious of poorer householders, claiming that they could not be relied on to cleanse houses properly, so the Corporation took over.⁶⁴⁴ This shows that whilst authorities could let residents undertake disinfection, this actually promoted negligence and prompted an increasing removal of autonomy from poorer sections of the community, contrary to Wohl’s argument.⁶⁴⁵

Deference emerges more clearly for optional disinfection, such as for tuberculosis. Manchester provides a rich example of how matters could become complicated when disinfection interacted with class. Initially, anti-tuberculosis disinfection was undertaken by householders themselves.⁶⁴⁶ The authority involved itself more clearly in disinfection from the late 1890s, but this was along class lines. Responsible householders could disinfect their houses, but those with dirty houses and where the disease sufferer was perceived to be unwilling to take precautions to limit infection were subject to the authority’s normal fumigation method.⁶⁴⁷ Those disinfecting for themselves were also advised to use the less invasive “bread” method.⁶⁴⁸ This involved rubbing walls with bread or dough, and was thought to work by capturing the germs in the sticky bread.⁶⁴⁹ It left wallpaper undamaged. Some researchers were in favour of it, but others regarded it as completely ineffective.⁶⁵⁰ This meant that the more distasteful and disruptive elements of fumigation were avoided for the better-off and

“more responsible” elements. Bolton, although undertaking the process themselves, also adopted this method for tuberculosis disinfection in 1891.⁶⁵¹ This concession to class-based property concerns was potentially damaging for disinfection in that it promoted less effective methods, and shows the overwhelming importance of retaining public support for policies. Offering an enhanced service for those who could pay was also not unheard of. Manchester would colour or limewash walls or ceilings, provided the owner paid upfront.⁶⁵² Bolton and Manchester were willing to apply innovative and gentler methods to the socially sensitive and, at the time the measures were introduced, an entirely voluntary process of tuberculosis disinfection; this indicates that ensuring that disinfection was not wholly off-putting to the middle classes was a key concern. Local areas were even willing to trade off efficacy, if it allowed access to more households, although they were not always willing to incur greater costs in order to do this, requiring householders to pay part or all of the costs of disinfection.

Tuberculosis disinfection was something of a special case due to the lack of powers to compel householders to comply, but this example shows that the middle class, the clean and responsible public, were regarded as able to undertake their own disinfection, whilst poorer, dirty and irresponsible sections of the population were subject to the more invasive local authority fumigation. In some cases, however, matters worked in the other direction. In St. Helens, householders who were too poor to pay for the cleansing of their houses were provided with brushes and whitewash to do the work themselves.⁶⁵³ This was in keeping with other areas. Poorer householders could also retain control over disinfection. The authority in both cases was nevertheless still involved in recommending the method of disinfection, setting the parameters within which householders were to act, and providing the materials. Householders were not far from authority influence even when acting for themselves. We can conclude that the public was willing to be subject to, or at least co-operate with, disinfection, with some expectations relating to tuberculosis. The ways in which this was achieved are explored in more detail in Chapter Five.

Providing Disinfectants: public services and disinfection

As we have seen, authorities were keen to direct disinfection and remove as much

of it as possible from the public's discretion. They did, however, want householders to use disinfectants at home according to standard directions, and therefore provided chemicals.

Chemicals were distributed in several contexts. Disinfectants were given out during outbreaks of disease; indeed, as we have seen, this had a long pedigree.⁶⁵⁴ The 1888 outbreak of smallpox, for example, led to large distribution programmes in several areas. In Preston, disinfectants and whitewash were distributed in "enormous" quantity.⁶⁵⁵ Manchester provided free carbolic acid powder to householders.⁶⁵⁶ The scale of the operation could be large. During the 1871 smallpox epidemic 3955 people received disinfectants in Bolton.⁶⁵⁷ This was not an atypical number, showing the acceptance of such programmes, concern over disease, and the resources that could be expended on disinfection. Disinfectants were also distributed free to individual households with a case of notified disease. Manchester provided free carbolic powder to householders throughout the latter half of the century, adding new disinfectants to the approved list as time went on.⁶⁵⁸ Carbolic, although a controversial choice due to its toxicity and apparent ineffectiveness, was a popular one; Liverpool gave out carbolic powder, with Preston and Bolton dispensing it in solution.⁶⁵⁹ Most areas gave these chemicals directly to affected households but others also allowed citizens to request or collect disinfectants from the sanitary offices.⁶⁶⁰ Bolton and St. Helens both allowed this by the early 1890s.⁶⁶¹ This suggests that citizens were increasingly expected to seek out disinfectants themselves, indicating this service was acceptable.

Most areas made a clear commitment to free disinfection services, as well as gratuitous distribution of disinfectants.⁶⁶² This was a point of ideology and pragmatism: as Preston Corporation argued, this meant that even the poorest had no excuse for not using disinfectants.⁶⁶³ As we will see, however, in Chapter Five, the stigma of charity could make any free item unattractive. This does not seem to have deterred all respectable people. Sigsworth and Worboys have argued that these free items, in particular whitewash

and the associated paraphernalia, were accepted and used.⁶⁶⁴ Some authorities were, rightly or wrongly, also wary of wealthier residents seeking free items and tried to limit such opportunism. Preston Corporation claimed that its intention was not to supply disinfectants to those who could afford them, or on a wholesale basis for trade.⁶⁶⁵ They seem to have been more suspicious than most, as no other authority studied made such statements. Preston limited the availability of the free disinfectants given out in 1903, provoking an angry statement by local Labour politicians.⁶⁶⁶ Whilst this could have been political jostling, it highlights the possibility that disinfectants were an appreciated commodity, which could be seen as an act of social benevolence as well as an imposition. This commitment to free disinfectants and disinfection was a central plank of the system and the key to marketing services as a way of helping out householders.

The provision of disinfectants was a key part of ensuring disinfection in the home. As we have seen, the choice of disinfectant could be problematic and there was great debate about which were effective. This was not reflected at local level. Most of the case studies show little or no discussion of which disinfectant to choose. Indeed, few were routinely explicit about which substances they were using, showing this was not a central issue. Where authorities mention their disinfectant supplies a trend emerges. Carbolic acid solutions and powders were the most popular choice, with chloride of lime and whitewash also frequently mentioned.⁶⁶⁷ Authorities also frequently changed the supplier of disinfectant used, even if the same chemical was used. The principles of economy seem to have had a strong hold and lower tenders were attractive. These conservative choices were not the most effective, but their low cost, familiarity and popularity seem to have given MOsH confidence in them. Some evidence of awareness of the problems of choosing a disinfectant does, however, exist. In Preston in 1897, Dr. Pilkington commented that *“the battle of the disinfectants was also again waged, and though each had its own advocate, there still remains ample room for one which can be proved to be at once cheap, efficient, pleasant, safe and easy to use”*.⁶⁶⁸ From this it seems that Preston had not been able to find a disinfectant that fulfilled everything they wanted. Whilst these comments were rare they offer a tantalising glimpse into the

problems MOsH faced. The choice of disinfectant hinged on cost and practicality, and was less affected by the detailed assessments of efficacy seen in the literature. This highlights once more the difference between theory and practice and the extent to which newer ideals about germicide were increasingly diluted.

Disinfecting Houses: methods of fumigation

Disinfection of dwellings was most commonly performed by fumigation. This was deemed an essential service that could “draw a line” under infection once the patient was recovered or removed.⁶⁶⁹ This section examines the provision for fumigation in the local case studies, showing the stability of methods over time.

Fumigation was in place from early in the century. Liverpool was the first area in the country to appoint a MOH in 1846.⁶⁷⁰ We might therefore expect Liverpool to be an early adopter of fumigation. While cleansing of houses was indeed undertaken from the 1840s onwards, it is not clear whether this included fumigation.⁶⁷¹ By 1862, however, Liverpool council was purchasing vitriol and chloride of lime, indicating that fumigation was probably occurring.⁶⁷² The 1871 outbreak of smallpox prompted an expansion of the process.⁶⁷³ Each sanitary inspector was equipped with a helper and a cart containing sulphur, carbolic powder, paper, paste and brush, and iron pipkins to burn the sulphur in. This handy kit was used to undertake fumigation when the removal, recovery or death of the patient allowed it to be used; even at this date Liverpool was not engaging in ongoing fumigation, probably for reasons of efficiency; by only fumigating once, staff only had to attend the house once. The actual process was relatively quick. The room was set up by mid-afternoon, then the sulphur was lit and left for two hours. For large rooms, whose use could be dispensed with, the chemical was left longer.⁶⁷⁴ The problem of dealing with inhabited houses, therefore, seems to have prompted a two-tier system which arguably skirted too close to ineffective fumigation. Thorough disinfection was only possible if the residents could be taken elsewhere, or if the house was large enough to allow the room to be out of service. The lack of accommodation for those whose houses were being fumigated was a problem in many of the case studies, and one which was not considered

until late in the century if at all.⁶⁷⁵ The limitations of local resources once again threatened effective fumigation and helped to persuade authorities to adopt processes the medical press regarded as ineffective. The practice continued over the next few years with little change to the method.⁶⁷⁶ The case study of Liverpool illustrates several key points; firstly, it shows that local authority disinfection was an intricate and detailed process, which was close to that recommended in the advice books of the 1870s. Secondly, it shows that fumigation processes were stable over time and were little affected by new concepts, at least before 1900, meaning they increasingly diverged from newer advice subsequently offered in the professional and scientific press.

This basic approach to house disinfection was reflected in three of the other case studies. Preston undertook sulphur fumigation from at least the 1870s, visiting Liverpool in 1874 to observe their practices, and it continued to be the normal response to disease for several decades.⁶⁷⁷ Bolton also undertook disinfection of houses on very similar lines. Sulphur fumigation was mentioned from 1871 onwards and remained in use throughout the rest of the period.⁶⁷⁸ St. Helens undertook a similar disinfection programme from 1875.⁶⁷⁹ Evidence from the County MOH reports also shows that sulphur was very popular with other authorities in Lancashire.⁶⁸⁰ The processes in these cases varied in detail but were essentially the same as the Liverpool approach.⁶⁸¹ The continuing use of sulphur fumigation long after the method had been discredited is of particular interest, and demonstrates the extent to which practice lagged behind scientific advice. Fumigation indicates that MOsH were influenced by a prevailing disinfection established before the advent of germ theory, which was difficult to change.

Fumigation was not without its problems. Several areas show increasing realisation that sulphur could be ineffective. Concern that exact directions be followed lest the method prove ineffective was expressed in Bolton from the 1870s.⁶⁸² These defects became increasingly important; St. Helens provides a useful example of this. Some doubt as to the efficacy of sulphur in treating diseases such as scarlet fever had

been expressed in the 1880s on account of repeat cases.⁶⁸³ By 1893 this doubt was more explicit as the MOH claimed that houses were fumigated “preparatory to a general cleansing down and limewashing”.⁶⁸⁴ The relative importance of the different aspects of the process was clearly shifting. Indeed, the MOH was well aware of the potential problems of sulphur disinfection, claiming it was “dubious” and attributing authorities’ success in preventing illness to the use of steam disinfection and post-fumigation processes.⁶⁸⁵ This emphasis on post-processes was repeated over the next few years, with this being seen as the key area in which neglect was occurring and causing repeat cases to emerge.⁶⁸⁶ This highlights the general shift away from confidence in sulphur disinfection. Despite this, it continued into the 1920s in some areas, demonstrating the tenacity of familiar practices where disinfection was concerned.⁶⁸⁷ The evidence therefore illustrates once again the conservative approach of local MOsH, even where they were aware of new research on the drawbacks of methods.

Manchester differed from other areas in its approach to fumigation and provides an interesting alternative vision of chemical fumigation. As with Liverpool, the city made an early foray into fumigation of houses from the 1860s onwards.⁶⁸⁸ The preferred method was somewhat unusual, as they used chlorine. As discussed in Chapter Three, this was used in a similar way to sulphur, and Manchester’s process was no exception. Council employees were to empty the house or room of inhabitants, seal it up, and fill the room with chlorine gas.⁶⁸⁹ The chemical was left for one to two hours before the windows and doors were opened and the room aired. Whitewashers cleansed the walls with caustic soda, removed the wallpaper, and treated the surfaces as necessary.⁶⁹⁰ This commitment to chlorine continued over the next few years and was repeated in the local press.⁶⁹¹ It is in significant contrast to the other areas and demands explanation. Unfortunately there is very little evidence as to why the policy was adopted. MOH reports, newspapers and council minutes do not include any detailed discussion of the thinking behind the policy, and the costs do not seem to have been lower than for sulphur.

It is difficult to explain Manchester's preference for chlorine.

As with sulphur, there were doubts about the effectiveness of chlorine. In the 1870s the MOH discussed some problems. Before they instituted the stripping and whitewashing of walls, reoccurrence of cases was "not infrequent", even in better houses.

⁶⁹² With the stripping policy in place this became "very rare". Chlorine alone was therefore unreliable, and required additional help from other methods. This disquiet was reinforced by specially commissioned research undertaken by respected bacteriologist and Fellow of Owens College, Sheridan Delepine, which demonstrated the bacteriological importance of washing walls with caustic soda.⁶⁹³

By 1897 the MOH claimed that they were "considering the advisability of abandoning [chlorine disinfection]" as it was "mostly accessory" to washing surfaces with chloride of lime.⁶⁹⁴

Manchester had come to the same conclusion as the other towns about the relative importance of chemical and mechanical cleansing. Despite these concerns, the authority continued to use chlorine until after 1914. Sulphur and chlorine were both increasingly discredited, but continued to be used. This could be explained by inertia or a rejection of the new germicidal research; this does not, however, account for why informed MOsH acted in this way. Statements about the effectiveness of fumigation reveal that whilst MOsH engaged with new research, they were concerned with more factors when devising a policy. Whilst fumigation was not ideal, they found it worked sufficiently well and they and their staff were familiar with it. Fumigation also had a strong cultural heritage which made it the obvious option when deciding to disinfect a room. Until other methods could meet these socio-cultural criteria there was no reason to switch to them.

This is reinforced by instances in which methods were changed. Some areas adopted the bread method as a means of disinfecting after tuberculosis; this was arguably a sop to middle class worries about their property. The new method of spraying also appeared in some areas. Liverpool used perchloride to spray wallpaper before stripping and fumigation, and extended this to spraying entire rooms.⁶⁹⁵

This largely replaced sulphur fumigation, and spraying accounted for 75% of all rooms disinfected from 1906.⁶⁹⁶ Liverpool also used formalin to spray some rooms from 1913.⁶⁹⁷ By 1913, St.

Helens had also moved to using formalin sprays for all the rooms it disinfected.⁶⁹⁸ This shift was in line with innovation in the most forward thinking areas. Brighton, directed by Arthur Newsholme, adopted formalin for the disinfection of tuberculosis in 1903, as did other authorities.⁶⁹⁹ Given that spraying had come to prominence only in the late 1890s, this was a relatively rapid adoption of new methods.⁷⁰⁰ There is no information on why this shift was made in these areas and the change was not controversial. It can be deduced that the ongoing concern about sulphur meant that when new methods were practical and available some authorities would switch. This innovation was not universal, and its importance should not be overestimated. Some areas adopted new methods but only on a small scale. Preston started to use formalin in 1911, but the method was initially limited in scope, with only 19 houses being treated this way.⁷⁰¹ Whilst some areas were interested in experimenting with new methods and adopted new approaches quickly, the overall process of innovation was comparatively slow, and they were more likely to stick to tried and tested methods that were believed to work tolerably well in practice and commanded the assent of the population. The lack of a sensible alternative to fumigation left authorities in a quandary: abandoning the method would undermine the overall process and method of disinfection, but, before 1900, there was nothing substantially superior to substitute. The reasonable response was to continue to use older methods. This highlights the continuity of practice over the second half of the century, showing that whilst germ theory changed the concept of disinfection it was not able to change the practice. This goes against assumptions that germ theory was instrumental in advancing more developed forms of practical disinfection.

Disinfecting Objects: Disinfection Chambers

The third responsibility of authorities was the disinfection of clothes and other textiles. As discussed in Chapters Two and Three, it was generally thought that clothes and belongings could spread infection.⁷⁰² Heat disinfection apparatus was therefore needed. The chronology and type of choices of heat apparatus in the case studies can be taken to indicate the relative attractiveness of the policies, and how changes in advice affected local areas. This section examines the development of such policies locally,

highlighting some interesting points.

The first important point is that some of the larger areas had heat apparatus before the 1866 Act. Liverpool had built a hot air disinfecting chamber at the gaol in the 1830s.

⁷⁰³ Manchester was the location of one of Dr. Henry's experimental hot air stoves, built in 1833, and funded by Dr. Henry himself.⁷⁰⁴ The apparatus used a furnace to heat a metal chamber and was still in use in the 1860s. Preston discussed the applicability of disinfection to paupers' clothes from 1849, and a disinfection stove was built at the workhouse in 1865.⁷⁰⁵ This further validates the suggestion that disinfection in towns occurred early on.

The disease preoccupations of the mid 1860s also seem to have provoked independent action from some of the larger cities. In 1864, the Liverpool MOH discussed the need for a disinfectant chamber which would allow the poor to disinfect unwashable items that were too expensive to destroy.⁷⁰⁶ He proposed chemical disinfection; the Sanitary Committee changed this to dry heat disinfection.⁷⁰⁷ This is one of a limited number of examples where councils opposed the recommendations of their MOsH and may well illustrate the lower status of MOsH in authorities at this point.⁷⁰⁸ It took until the arrival of cholera in 1866 to prompt the council to spend money on four disinfecting stoves, based on Dr. Henry's dry heat design. Delays in the construction of apparatus were also common throughout the period, reflecting the problems of getting anything done rapidly at local level which Hamlin has identified.⁷⁰⁹ The stoves were initially run at a pressure of 8 lbs per square foot, but as this damaged the machinery and incurred significant repair costs, the pressure and temperature had to be reduced and regulated.⁷¹⁰ Achieving the desired temperature at a pressure which did not damage the apparatus was a problem, and shows the compromises that needed to be made in practical disinfection. The costs of the apparatus were excessive compared with those in other areas: it cost £892 to build and £4.7.0 a week to operate. It also proved to be costly over the next few years: in 1867, the council spent £4,722 on expenses relating to the disinfecting

apparatus, including a hefty repair bill.⁷¹¹ Despite these problems Liverpool pressed on with extending provision to the rest of the city. The New Bird Street apparatus opened in 1867.⁷¹² The council once again encountered some problems with running the apparatus and were forced to adjust the process.⁷¹³ The reliability of early machines was clearly a problem, but did not deter councils from providing them.

Manchester also made arrangements for new disinfecting apparatus in the early 1860s. As in Liverpool the existing machinery proved insufficient and new apparatus was needed.⁷¹⁴ The council considered what was used in other towns, including Dublin and Leicester, and sent a representative to Liverpool to investigate their arrangements.⁷¹⁵ The efficacy of apparatus in these towns was seen as justification for Manchester to follow suit, as was the presence of diseases. It was also a matter of pride; it was embarrassing and inconvenient that they were not leading the field.⁷¹⁶ The importance of communications with other towns, and of civic pride, is evident in these debates. Unlike the Town Hall, disinfection apparatus was not a prestigious symbol of municipal pride, but the ethos described by historians such as Tristan Hunt and E. P. Hennock is evident.⁷¹⁷ The recommendation was quickly adopted, and a smallpox epidemic made it more pressing.⁷¹⁸ The council had trouble finding a location, and eventually settled on a site belonging to the Gas Committee, located near a public park. The proximity to valuable urban green space caused significant concern for the local residents, who organised a petition and public meetings against the disinfection ovens.⁷¹⁹ They feared that the risk of infection would threaten them and the value of their property.⁷²⁰ This objection was also raised in Bolton, and was a common reaction to isolation hospitals.⁷²¹ The health committee in Manchester, and other towns, attempted to counter the concerns and argued that the clothes would be disinfected so well and be so innocuous that “concern would fade away”. They pointed to the nuisance-free use of the apparatus in other areas such as Liverpool.⁷²² Whether this was successful is unclear, but the resolution to build the

ovens was passed and they were built at New Allen Street.⁷²³ The apparatus used dry heat and chlorine gas.⁷²⁴ It was “amply sufficient” and had “excelled all expectations”, and had also avoided danger to nearby residents as it produced no smell or nuisance, and thus had no risk of outside infection.⁷²⁵ The experiences of both Manchester and Liverpool show that in the larger areas, heat disinfection was considered important enough to upgrade equipment in the 1860s, and that disinfection preceded the 1866 Act. The role of epidemics in hastening the move towards new apparatus is also clear; a pattern which was repeated throughout the other case studies.

After 1866, new provisions were enacted in the other towns. Preston provides a good example of a town in which municipal provision emerged in the 1870s. The idea of a municipal disinfecting apparatus was raised in 1874, and was aimed at preventing the reckless use of infected clothes and the consequent increase in mortality.⁷²⁶ Diseases and public negligence were a key pressure towards establishing an apparatus. The example of other towns was also a motivating factor and the Sanitary Committee noted the successful use of apparatus in Liverpool, Bolton and Blackburn.⁷²⁷ The council agreed, and sought advice on methods of disinfection from Liverpool, Birmingham and Nottingham, and made visits to Liverpool and Oldham to observe the processes.⁷²⁸ Networking, rivalry and information sharing were evident in many areas of disinfectant policy, and is discussed in more detail below. The findings resulted in a plan to construct a hot air apparatus which could be used with chemical disinfectants if necessary. Construction progressed quickly, and the building opened amid publicity highlighting the apparatus was free to use.⁷²⁹ Bolton had a similar trajectory. The town constructed its first disinfectant chamber in 1870, a relatively rapid move for one of the smaller urban centres which at this point lacked a full-time MOH. It used dry heat of 230-250 degrees Fahrenheit.⁷³⁰ The decision, as with other ones, provoked no comment, and it seems that the proposition was routine rather than a contentious act of policy making.⁷³¹ Disinfection apparatus could be quick and easy to adopt and did not depend on a

developed public health programme.

The case studies show the impact of changing preoccupations and problems. As we have seen, Bolton installed its first apparatus in 1870. It initially provided good service, but rapidly deteriorated and by 1874 had become “dilapidated, expensive, and insufficient for the needs of the town”.⁷³² The investment in the chamber clearly did not result in long term effective disinfection to the standards demanded by the new MOH, necessitating a new apparatus.⁷³³ Visits were made to Liverpool and Manchester to inspect their apparatus, and letters were sent to other towns, once again showing the extent to which experience was shared among the medical professionals and town councils.⁷³⁴ They decided on a new hot air disinfectant chamber, combined with a furnace for destroying items.⁷³⁵ The council had therefore updated its apparatus according to the most commonly recommended advice at the time, and fallen in line with most of the other case studies. On the other hand, there is evidence of significant delays in adoption in some areas. St. Helens first installed hot air equipment at some point in the 1880s, much later than most other places.⁷³⁶ The smaller size of the town and underdeveloped local administrative structures are likely to account for this. This is supported by evidence from the County Council reports, which shows that smaller and rural areas were much less likely to have installed any form of heat apparatus even by 1910. The size of the authority, and the resources it could command, were crucial determinants of the timing of new developments.

The 1880s saw the advent of steam disinfection, prompting other areas to upgrade their practice. The chronology of the application of this method in the case studies is interesting. Liverpool was the first to make the move to steam, converting the existing apparatus in 1871.⁷³⁷ Economy was clearly important in promoting the adaptation of old apparatus. By the 1890s apparatus dating from the 1870s had become inadequate for the city’s needs and a replacement was required. A steam disinfector on the design of Messrs. Manlove, Alliot and Co. was opened at Chisenhale Street, Liverpool, in 1894.⁷³⁸ This shows that the council had decided to update their apparatus along more modern lines,

although existing older apparatus remained in operation. Both Bolton and St. Helens also made the move to steam apparatus, in 1884 and 1893 respectively.⁷³⁹ Both found it helpful for their public health needs.⁷⁴⁰ The delay in the adoption of new apparatus, also reflected in Manchester, and the fact that the areas made no further changes before 1914 shows the lag between ideas and practice, and the extent to which once a system was effective there was no need to incur further expense and disruption by changing it.⁷⁴¹

The move towards constructing specialist isolation hospitals also added to the adoption of steam apparatus in the 1880s. These institutions were invariably provided with equipment, usually on a steam pattern, which was used to treat the items used in the hospital, as well as the patients' clothing and bedding.⁷⁴² As the proportion of cases isolated rose in the late 1880s and early 1890s, the location of disinfection shifted.⁷⁴³ For example, by 1910 over half of the disinfection done in St. Helens took place at the hospital.⁷⁴⁴ This added a new way in which the authority could apply heat, and was a key factor in the increase of items disinfected. Ensuring the disinfection of as many items as possible also led to innovations. As we have seen, most authorities opted for fixed apparatus. This could be problematic. For those with only one set of clothes, the threat of their removal to the apparatus could provoke the concealment of cases.⁷⁴⁵ Manchester tried to find a remedy, and was the only case study to experiment with portable apparatus. This was instigated by their disinfection advisor, Delepine, who invented and supplied them with a portable steam apparatus. The authority also provided clothes for people to wear whilst they waited.⁷⁴⁶ A close relationship with an "expert" could promote innovative methods. The apparatus was not as popular as they hoped, and discussions of it disappear from the record fairly quickly.⁷⁴⁷ Experimentation was not guaranteed to succeed, and towns took risks at their own financial peril.

This failure of the Manchester apparatus highlights the problems of adopting new methods. As mentioned earlier, Manchester showed long delays in adopting steam; they converted their hot air apparatus only in 1897 on the advice of Delepine.⁷⁴⁸ This use of

existing resources was regarded positively. They claimed that the apparatus was “for practical purposes efficient, and [was] capable of disinfecting an enormous quantity of items”.⁷⁴⁹ St. Helens also only opted for steam in 1893.⁷⁵⁰ The MOH was confident that modern steam apparatus destroyed the “disease poison” very rapidly.⁷⁵¹ Whilst accepting the arguments for a change of apparatus, practicalities had made the *status quo* more attractive. Preston in particular was most content to keep its hot air apparatus long past the point where other areas had adopted new methods. Dr. Pilkington defended it, claiming in 1887 that whilst it was “perhaps inferior to superheated steam” he had found it worked satisfactorily in Preston.⁷⁵² Experience of the benefits of an apparatus were more important than research in governing decisions, and authorities tended to upgrade it only when it was no longer of practical use, and, in doing so, usually purchased something more technologically advanced.

The decision to change apparatus in 1901 shows the opposite trend. By 1901, Preston’s dry heat apparatus was “somewhat antiquated” and the decision was taken to replace it with a steam disinfecter.⁷⁵³ Dr. Pilkington emphasised that the old apparatus was still in excellent working order but was “antiquated” and “not up to the requirements of modern science”.⁷⁵⁴ The innovation in this case was motivated by new research. The change of attitude is difficult to understand fully, but the essential conservatism of approach is clear. This conservatism can also be seen in Lancashire more generally. Many authorities lacked suitable disinfecting apparatus even after 1900, either due to inadequate methods or not having any at all.⁷⁵⁵ Despite the County MOH, Dr. Sergeant’s attempts to “name and shame” large authorities which lacked suitable equipment there was relatively little change over the period 1890-1914.⁷⁵⁶ Progress in smaller authorities across the county was slow and lagged behind even the most conservative of our case studies. Steam was not the universal attraction the literature assumed it to be. These examples demonstrate the complexities of adopting heat apparatus. Whilst agreement over the technology was widespread there were significant problems over practicalities, including location and type of equipment, and progress on

the ground was generally far more gradual than the recommendations in the advice literature, even though local MOsH had accepted the need for heat disinfection.

The changes in steam apparatus highlight an important factor in disinfection, namely that councils did not usually disagree with their MOsH over policies. There is little evidence of disputes. In Bolton, the committee initially decided on apparatus from Manlove, Alliot and Fryer, but, on the recommendation of Dr. Sergeant, who was then MOH for Bolton, agreed to switch to buying a Washington Lyons Steam Disinfector.⁷⁵⁷ Dr. Sergeant was clearly sufficiently aware of debates about different types of equipment to use this information in his decisions. These debates were not picked up by the newspapers, demonstrating the extent to which disinfection policy was readily accepted or was considered too uninteresting to merit discussion.⁷⁵⁸ The expertise of the MOH was accepted without contention in this case. This was a common theme throughout the case studies, and raises some interesting points about the location of disinfection expertise. Hamlin has shown that making the wrong decision in water supply could lead to legal action against councils and considerable stress.⁷⁵⁹ Serious consequences relating to disinfection were uncommon. The purchase of the steam disinfector in 1893 meant that St. Helens became embroiled in a complicated patent conflict, eventually having to pay Mr. Washington Lyons, the patentee, an additional £100, a not inconsiderable sum considering the machine had originally cost £205.⁷⁶⁰ St. Helens seem to have been put off making further changes to their municipal machinery before 1910, although they did buy new apparatus from Manlove, Alliot and Co. for the borough sanatorium in 1908.⁷⁶¹ Whilst councils were the main customers for disinfection apparatus they also seem to have been in a position of weakness when it came to disputes. However, this was uncommon, highlighting that the repercussions of making the wrong decision were less than for other areas of policy.

The visibility of conflict can also be seen as a factor in disputes. Unlike water supply, in which Hamlin has identified that conflicting opinions were obvious to local councillors and caused significant debates, disinfection was sufficiently removed from popular attention and commercial pressures to avoid such problems and was not reported

in the news.⁷⁶² Indeed, the absence of debates about disinfection from the council committee minute books of all the case studies, and the local press, contrasts starkly with other policies such as isolation and notification. The apparent distance of the debate from public view was a clear influence over this lack of attention, but cannot be considered the only causal factor; if the press had reported on the issue more, it would have been likely to be more controversial. The lack of discussion in any source consulted is surprising, given the generally controversial nature of public health in this period in terms of public reaction, local politics and costs.⁷⁶³ The complete lack of disinfection debate in local politics is interesting, and perhaps shows that it was not a topic people rallied behind. Disinfection was not a contentious topic, indicating that it was treated as routine, and was generally accepted by all those involved. This highlights the ways in which policies could be uncontroversial, and reminds us of the parts of public health that did not cause serious local political problems.

What affected policies?

As we have seen, disinfection policies in the three main areas of chemical disinfection, fumigation and heat disinfection remained remarkably stable over time. What factors might have affected these policies? One key concern is the influence of germ theory on local thinking. There is clear evidence that at least some of the case study areas were considering their policy in terms of germs. As we have seen, most areas started a disinfection policy before germ theory was fully articulated or developed, showing that the older ideas of disinfection were influential in prompting the adoption of a policy. MOsH blended old and new ideas throughout the period, linking “contagion” and “disease causing particles” to “germs”. For instance, in 1879 Dr. Sergeant discussed disinfection, and claimed that it would remove the “contagious particles” of disease.⁷⁶⁴ These were “particulate and dangerous”, sharing many of the characteristics of germs. By the mid-1880s he was more convinced of the need to kill germs.⁷⁶⁵ Similar sentiments were expressed in the other case studies during the 1870s and 1880s.⁷⁶⁶ As time progressed, the focus on germs increased. Manchester in particular was very well informed. The MOH, Mr. Leigh’s, reports show that he was familiar with Pasteur, Liebig

and other authors, and explicitly linked his practice from the 1880s onwards to the need to destroy germs.⁷⁶⁷ Dr. Tatham, his successor, commissioned research on a number of topics from Sheridan Delepine as a way to assess the germicidal effectiveness of his practice.⁷⁶⁸ Manchester was the most innovative area in many ways, experimenting with new policies and showing a much greater interest in research. The presence of Owen's College was important in allowing access to researchers, although it seems that Delepine and Tatham were also friends. This level of interest in germs was unusual, with some areas retaining older ideas as well as sanitarian notions. Dr. Pilkington, Preston's long serving and rather old-fashioned MOH, continued to regard various things as important in disease transmission. Beier has pointed to Dr. Pilkington's use of differing theories of diphtheria causation in 1889.⁷⁶⁹ Pilkington's "old school" approach to disinfection could be seen to be linked to his conservative approach to policy more generally. It is difficult to see whether this made disinfection ineffective, although Preston was notorious for its high death rates. Towns which were more active generally were likely to experiment with newer, more innovative disinfection policies, but there were few major differences in disinfection policy between the various areas. Disinfection policies were generally unresponsive to wider change and remained conservative throughout the period. Germ theory, whilst able to prompt some changes, was unable to unseat the general approach.

The outside influences that affected these policies are also of interest. There is clear evidence that the different areas were communicating and sharing information. Preston enquired about disinfection policy in other towns, and Mr. Pilkington visited Liverpool and received advice from its MOH, Dr. Trench.⁷⁷⁰ Manchester also made similar enquiries in the 1870s and a detailed fact-finding visit to Liverpool.⁷⁷¹ This is in line with wider understandings of the roles of urban networks in the development of public health policies.⁷⁷² There was also awareness in the localities studied of the ideas and policies promoted by the LGB. Circulars were used in several of the case study areas, although linking this directly to changes in policy is difficult.⁷⁷³ Dr. Parsons' LGB research on steam disinfection was used to support purchasing new apparatus in Bolton,

but does not seem to have been a driving factor in the initial choice to construct new apparatus.⁷⁷⁴ Such information was also publicised directly to the public.⁷⁷⁵ Direct contact also had an impact in some cases. In Preston a LGB inspector who visited the town to advise on the smallpox also recommended that the town clerk write to the LGB to request copies of the system of disinfection which the Board believed to be best.⁷⁷⁶ Whilst this communication could be important in exposing towns to policies from other areas, and the suggestions made for best practice, this was at best a sporadic influence; each town made its own decisions and policy.

Towns were most likely to look to their neighbours for advice, but some also looked further afield. Authorities either canvassed a wide range of towns, or identified towns with similar characteristics and made enquiries. There was also a bias to larger towns, demonstrating that MOsH were aware that these were at the forefront of policy. The networks of local interaction therefore highlight several themes. Towns with innovative policy attracted more attention, as did certain more activist MOsH, but this was not a universal way in which policy was affected. Networks were impermanent and shifting according to the short-term policy preoccupations of the towns involved, but could be influential in policy development.⁷⁷⁷ These types of interaction were nevertheless haphazard at best. Towns formulated their own policies and sought outside advice on their own terms, and were not averse to ignoring the information gained if they did not approve of it for whatever reason. In this way, whilst ideological and theoretical factors were an influence, they were not the defining influence and changes in disinfection policy trailed a significant way behind advances in advice literature.

Pragmatic factors were also important. As we have seen, ineffectiveness or unreliability of apparatus was a key factor in prompting new acquisitions. This can be seen as parsimony, as well as being influenced by the desire for basic effectiveness of the equipment. Whilst most authorities were not at the cutting edge of research, they required a basic level of service from their equipment. The costs of disinfectants was also a concern, with local authorities changing supplier frequently; this cannot be attributed to any formal rules about tendering. There are no discussions of why this was, but it is fair to presume that value for money would have been a concern. How much did it cost

authorities to undertake these policies? Tracking the costs of disinfection over time is difficult. The larger case studies show that it could be expensive. In 1913, Liverpool had spent £1,746 on disinfecting houses.⁷⁷⁸ This was a large sum, but when considered in relation to the size of the population of over 700,000, it was not unreasonable.⁷⁷⁹ Manchester estimated that disinfection for tuberculosis alone would cost £1,000 per annum. This was 40% of the overall projected costs of the tuberculosis prevention programme, showing that disinfection could be a significant expense.⁷⁸⁰ The costs of equipment and other necessities could mount up quickly. Staffing costs are a good example of this. The larger the town, the larger the staff, and these grew over time. In 1890, Liverpool had nine disinfecting inspectors working for the MOH, as well as attendant staff for the disinfecting apparatus.⁷⁸¹ By 1914, there was a superintendent of the disinfecting apparatus, a superintendent of the stripping staff, twelve disinfecting inspectors, and two apparatus attendants.⁷⁸² Other towns had smaller teams, but all had at least two staff members assigned to disinfection.⁷⁸³ Disinfection used various types of staff. Sanitary inspectors, who were required to be qualified from 1877 onwards, were heavily involved in the running of day-to-day health policy in the towns and were comparatively expensive due to their qualifications and increasingly professional status.⁷⁸⁴ Disinfection inspectors did not necessarily have the same level of qualifications, although where sanitary inspectors were used to undertake disinfection they would have had the relevant qualifications.⁷⁸⁵ Other staff, such as whitewashers, were unskilled and were paid less. The combined wage bills were not inconsiderable and staff costs were a significant part of the costs of disinfection. Local authorities devoted significant sums to the day-to-day running of disinfection. Cost was not discussed as a problem in any of the case studies and, when compared to the amount of work done, disinfection seems economical. Whilst costs could be high, these were not necessarily a severe limiting factor, and were not raised as a problem.

Was disinfection effective?

As we have seen, disinfection was a widespread policy, but was it effective? We

can judge this in a number of ways. Did contemporary practitioners believe the policy was useful? What evidence did they put forward? Can we identify any demographic influence? Some of the MOsH contemplated the failures of disinfection to prevent infection. The St. Helens MOH in particular took an interest in the levels of disinfection failure and charted its failures for scarlet fever.⁷⁸⁶ Manchester also shows several cases where the families and friends of disinfection staff contracted scarlet fever. Although the MOH did not explicitly link these cases to their work, given that this was listed as the probable provenance of the disease he evidently recognised that the disinfectors could themselves be infectious.⁷⁸⁷ This did not trouble the authority excessively, but the concerns this raised about disinfection are clear. Others demonstrated some suspicion of disinfection in their actions. An incident in Bolton in 1893 illustrates the limits of professional faith in disinfection. During an outbreak of smallpox, two infectious cases dutifully presented themselves, along with their notification certificates, at the Sanitary Office at the Town Hall. This rather unorthodox route to isolation and disinfection caused serious concern for the council. The Sanitary Office was fumigated twice, and otherwise disinfected.⁷⁸⁸ Normal houses were disinfected only once despite the fact that they had usually been occupied for a significantly longer period. Clearly, the threat of smallpox to council staff merited an unusually thorough cleansing of their offices, and demonstrates the limits of trust in disinfection when it came to their own safety. Manchester also doubted the safety of their staff. The whitewashing staff contracted several cases of illness from infected wallpaper, even though these papers had been treated with both chlorine fumigation and carbolic acid.⁷⁸⁹ This danger to the men was offset by greater safety for the public. Although there had been several repeat cases before the post processes were added to fumigation, these had nearly been eradicated after the new approach was introduced.⁷⁹⁰ This discussion, whilst maintaining the overall positive message about the eventual effectiveness of disinfection, highlighted how fumigation in particular was a partial solution and that there was cause to doubt aspects of disinfection, despite the positive attitudes of MOsH.

Indeed, the usefulness of disinfection for certain purposes could be questioned.

The Preston MOH commented that whilst disinfection was undertaken for tuberculosis, he thought that general sanitation rather than attention to the particular germ was more important.⁷⁹¹ The overall message about disinfection was, however, positive. The MOsH in the case study areas were enthusiastic about disinfection in their discussions, took it as read that it was an effective policy, and saw it as an important part of their public health programme.⁷⁹² Disinfection was not questioned as a general policy, even where specific aspects were problematic, and it continued to appear in reports throughout the period. Its effectiveness was usually positively approached. For example, the Manchester MOH claimed that his disinfection apparatus was so effective that the bedding of smallpox and scarlet fever patients had been slept in immediately with no bad results. No case of fresh infection from a “disinfected” item had been found despite careful inquiry by the MOH.⁷⁹³ This effectiveness of the policy was emphasised by other MOsH, who highlighted the low failure rates of their policies. Indeed, some failures of disinfection were not seen as failures at all, but as evidence of the tenacity of the disease poison.⁷⁹⁴ This case tracing method, as discussed in Chapter Seven, relied on the practical application of disinfection and reinforces the point that the needs of local authorities were not generally met by laboratory research. It was, however, sometimes thought that research also supported the validity of their methods.⁷⁹⁵ This related to specific, practical research undertaken for the authority; laboratory research could be useful only if undertaken in a particular way. This research was seen as proof of the effectiveness of disinfection. For the MOsH studied, disinfection was an accepted part of infection prevention; it was only the details that could be troubling. Disinfection was not a glamorous policy but went on steadily in the background, attracting little controversy and enjoying high confidence levels.

How well founded were these confident statements? Given that disinfection was included within isolation and notification, it is difficult to disentangle the effects of these individual processes and assign a value to an individual element of the system. The policies also evolved alongside a range of other public health measures, including the provision of sewers and water supplies, the demographic effects of which are contentious

and much discussed.⁷⁹⁶ It has not been possible within the remit of this thesis to analyse the demographic patterns in the towns for signs of whether disinfection, per se, reduced mortality. There is some evidence which indicates that disinfection could have been helpful. There are some comments in the historiographical literature to suggest that disinfection could be effective in reducing mortality from certain diseases, provided it was combined with notification and isolation and was carried out thoroughly enough.⁷⁹⁷

If these conditions were not met then disinfection could prove ineffective.⁷⁹⁸ All of the towns saw a downward trend in their mortality levels over time, and a decline in cases of infectious disease, a large proportion of which can be attributed to the role of social intervention and public health; whilst disinfection may well have been a small proportion of this, its potential contribution should not be overlooked.

The importance of disinfection can also be seen in the acceptance of the policy by key stakeholders. Whether effective or not, it was regarded as important by the professions, councils and also, eventually, by the public. It also encouraged an awareness of what might be done to reduce infectious disease, which was arguably helpful in encouraging the kinds of public awareness and behaviour change the public health profession desired.⁷⁹⁹ As Tomes has argued, bringing the “gospel of germs” into domestic routines was important in shaping behaviour in relation to disease. Disinfection added a scientific veneer to this process, and a service which the public were often willing to use. This allowed a way for the local authorities to collaborate with the public and promote disease prevention. Disinfection was an important part of a developing germ-aware popular culture, which empowered the public to fight an active, day-to-day battle with disease, and had wider effects in changing behaviours. This was not without complications, as the next two chapters show, but can be seen as a generally positive development in relation to public health reductions in mortality. Policies such as disinfection, which provoked relatively little opposition and was generally agreed upon by population and authorities, encouraged co-operation and behaviour change, and can therefore be seen to have materially contributed to improving health in the late nineteenth century.

Conclusion

Disinfectant practice at local level reveals several interesting points. The first is the increasing capacity of local authorities to undertake disinfection. The progress of legislation demonstrates that MOsH were accorded increasing power and responsibility for disinfection, tipping the balance from householders to the authority. This rested on the increasingly specific nature of disinfection; in order to ensure effectiveness disinfection had to be placed in professional hands. This is a significant finding, and shows the increasing willingness of central government to impose it in a mandatory fashion on the population, running counter to other policies, such as vaccination, in which opting out was allowed.⁸⁰⁰ The local studies also demonstrate the continuity of an ongoing environmental focus of policy in practice, showing that the purported move to people-centred policies, with the rise of germ theory and notification, was not universal across all areas of intervention.

The case studies additionally reveal that local areas were undertaking disinfection in the decades before both germ theory and the 1866 Sanitary Act; disinfection was a prior policy and considered a matter of independent importance. The expansion of public health policies in the 1870s did, however, prompt a move to wider disinfection policies. Authorities made their policies routine, applying them to increasing sections of the population and to a wider range of locations and diseases. This made municipal disinfection a normal, and unusually well-accepted, part of the experience of disease for most classes of householders by the 1890s. Public opinion about germs made disinfection acceptable, and prompted householders to accede to the municipal services. This general consensus about the worth of disinfection can also be seen in the extent to which it was not a politically sensitive or widely-discussed issue. The policy thus commanded an unusually high level of support from the public, the press and local politicians, showing that not all areas of public health were contentious and that some preventive health measures could be advanced comparatively smoothly.

The development of the details of policies are also revealing. Local areas were extremely conservative in the methods they applied, using “outdated” techniques long after credible alternatives had been accepted by the professionals. They preferred those which had proved effective and were deemed practical, and were only prepared to adopt

new methods where they fulfilled these criteria. In this way, practice followed a different trajectory from theory. Since the concerns of MOsH were grounded in making disinfection policies simple to implement there was a complicated relationship between theoretical best practice and the realities of disinfection methods used. Despite the changing science and definitions of disinfection, practice remained mainly the same in these five localities during this period. Other influences over policy are less evident. Local politics, costs, rivalries and professionalism have all been mooted for other areas of policy, but do not seem to have been of significant influence in disinfection.⁸⁰¹ Indeed, the significant lack of debate or controversy over the policy is extremely interesting and highlights that public health was not always a fraught subject. The evidence from the case studies forces us to rethink our ideas about day-to-day public health policies and their social and political impact.

Chapter Five: Property, the public and disinfection

This chapter examines the impact of concerns about property on disinfection. The disinfection of objects and houses brought authorities into contact with the property of different groups of people, and raised the question of how the needs of disinfection were balanced against the avoidance of damaging or destroying objects. Hennock claimed that disinfection routinely led to the “virtual destruction” of belongings, and was thus avoided and resisted by householders.⁸⁰² The evidence investigated here shows that, whilst this could be the case, the picture was far more complicated. The ways in which disinfection attempted to avoid these problems will be examined, and the various moves towards accommodating the needs of property identified. These show the problem of extending effective disinfection to a wider population with an increasingly varied range of items that needed treatment. The tensions between the two needs reflect the disagreements that could erupt between the requirements of public health and the wishes of the population, and show the accommodations that had to be implemented to make a policy sufficiently acceptable to ensure compliance. How the public viewed disinfection is of crucial importance. Public interest in disinfection increased dramatically from 1880 onwards, and the range of ways they could be involved in day-to-day operations increased. Their role was, however, ambivalent. Professionals regarded the public as unable to undertake

effective disinfection, and took steps to try to mould and “correct” erroneous public knowledge and practice. A key area of concern was how to minimise the practical impacts of disinfection techniques on property, removing one of the barriers to public acceptance of disinfection. This was, however, complicated, as the second half of the chapter shows. Some items were essentially “undisinfectable”, prompting extreme measures which tested public tolerance. The limits of the compromise between public opinion and effectiveness illustrate the way in which disinfection could be moulded by practical and cultural factors.

Patents, potions and perplexity: how were the public approaches to disinfection portrayed?

A key area of investigation is how the public themselves viewed disinfection. This can be split into two main questions: how did the public approach disinfection within their own homes, and how did this intersect with the professional provision supplied by the local authority? This section examines the extent to which the public participated in disinfection themselves, and the responses of those providing more “effective” disinfection.

There is some evidence that the public was undertaking disinfection in the first half of the century. Tomes has argued that disinfection was practiced by the US public before 1860.⁸⁰³ Judging the situation in England is difficult. There is some evidence that the public believed in the power of rudimentary disinfection. Worboys and Sigsworth have described an incident in 1849 in a suburb of Sheffield which illustrated concern for a form of disinfection. Local residents apparently ignored official advice on cholera, but instead stood outside the local alkali factory for days on end; they believed that the fumes were both protective and disinfectant.⁸⁰⁴ Others burnt bark and other substances to cleanse the air. Use of more orthodox disinfectants also appears in some texts. In 1862, a Liverpool woman who lived in a run-down court mentioned her use of “stoving”, meaning sulphur fumigation, as a cleaning method.⁸⁰⁵ This practice seems to have survived into the twentieth century in Barrow as a combined germ-preventative and treatment for chickenpox and measles.⁸⁰⁶ There is also more direct evidence of a limited

market for popular disinfectants, as some branded disinfectant products appeared from the 1840s onwards.⁸⁰⁷ These were being purchased by sections of the public, as evidence from cases of accidental poisoning show. Nevertheless, the extent of popular disinfection is likely to have been limited, and the public received only limited direction on disinfection practices.⁸⁰⁸

By the early 1880s there was a wide range of popular literature on disinfection. An increasing number of popular texts on various disease prevention topics mentioned disinfection and offered advice on disinfectants, methods and practices. Some of these were explicitly aimed at the educated classes.⁸⁰⁹ Disinfection rules, for example, appeared in Mrs. Beeton's *Book of Household Management* from 1883 onwards.⁸¹⁰ Other, more specialist popular texts, which were probably aimed at the middle classes, also made pronouncements about the need for disinfection.⁸¹¹ *Germs, Dust and Disease*, published in 1883, included a detailed list of practical precautions to take when infectious disease was raging.⁸¹² These types of pronouncements were repeated in many similar texts over the years. Some more widely-aimed advice texts for mothers also included limited sections on disinfection.⁸¹³ Disinfection advice also appeared in several of the local papers studied, as well as in the national papers.⁸¹⁴ Disinfection was thus a clear part of the advice offered to the educated and interested middle class, but this was far from universal. Some texts on disease prevention did not cover disinfection.⁸¹⁵ Some popular handbooks on related topics included little or no information on disinfection.⁸¹⁶ This literature is also unlikely to have had a large working-class readership; whilst V. Smith has argued that popular health texts were designed to be read by a full range of the educated classes, Tomes claims that in the US the working classes generally did not consume popular health texts until after 1900 due to the cost.⁸¹⁷ On balance, it seems that whilst some working-class readers would have had access to such texts this was probably uncommon. Whilst local papers did include instructions on disinfection from

the 1870s onwards, and increasingly contained advertisements for disinfectants and soaps from the 1880s onwards, there is also doubt regarding readership.⁸¹⁸ D. Vincent has argued that by 1914 there were still sections of the population too poor to afford newspapers; Rowntree's investigation of York showed that nearly half the working class population could not afford regular purchases of newspapers, although when income permitted, newspapers were a popular choice, and were also available in public libraries.

⁸¹⁹ The public was therefore receiving increasing information about the specifics of disinfection, although the extent to which this was reaching everyone is unclear.

Disinfection advice usually took a standard form and detailed the causes and symptoms of common diseases, the management of the sick room, the objects needing to be disinfected, and the methods required to do this. The advice blended professional practice, such as municipal steam disinfection, and self help practices such as boiling.⁸²⁰

They also familiarised the public with the processes of municipal disinfection.⁸²¹ This accords well with Tomes' claim that disinfection was adopted with relative ease in popular texts as it provided a germ-theory rationale for existing domestic practices.⁸²²

Advice texts also recommended easy-to-follow methods because, as Roose recommended, disinfection needed to be simplified in order to make it more popular and attractive, whilst having due regard to efficacy.⁸²³

The public were therefore receiving a more simplistic message than was accepted in professional circles. These instructions also showed a greater tendency to highlight older, more dubious practices alongside professional advice.⁸²⁴

The recommendation for saucers of disinfectant to be placed around the room as a way to "disinfect the air" was a particular point of dispute.⁸²⁵

Popular texts lagged behind professional works in their chemical recommendations.⁸²⁶

They also often recommended commercial disinfectants, as they were more pleasant for use in the home.⁸²⁷ Unsurprisingly, advice pamphlets published by disinfectant

companies were most likely to recommend their own products.⁸²⁸ There is evidence that

the detailed instructions were taken up by the public, and some mothers followed the complexities of the advice, such as hanging disinfectant soaked blankets at the door.⁸²⁹

Popular texts did not, however, entirely eschew professional practices. They recommended that the householder consult their medical practitioner about disinfection; this alone shows these texts were aimed at the middle class.⁸³⁰ Whilst some authors allowed for the public to disinfect objects by themselves, there was an increasing move across the period from 1879 to 1900 towards methods, such as steam, that had to be undertaken by the local authority.⁸³¹ Some popular texts also made explicit recommendation that the public utilise these facilities and allow the authorities to do their job.⁸³² Gay, for instance, recommended that whilst boiling and destruction could be done by the householder, the more difficult processes of steam disinfection and use of chemicals should be left to the sanitary officers.⁸³³ The role of the authority in providing advice was also a concern in some texts. A pamphlet on cholera recommended that the householder should inform the local MOH as soon as the case was discovered, and that disinfectants and instructions for their use would be supplied by the sanitary inspectors.⁸³⁴ The author, however, recommended that the public should also use carbolic for general disinfection. This flew in the face of letting the local authority choose the disinfectant and shows the ambiguities of ceding control. The public was advised to seek professional help in certain aspects of disinfection, but were also encouraged to recognise their own role.

This proliferation of advice allegedly promoted the sale of disinfectants. One author attributed the steadily increasing demand for disinfectants to greater public awareness of “the true causes of zymotic disease” and desire to prevent their spread. This had stimulated innovation in disinfectants so that many had been introduced in recent years.⁸³⁵ Indeed, the proliferation of popular disinfectants in the period after 1870 can also perhaps be taken to indicate a growing awareness of disinfection. One of the most high-profile disinfectants of the later nineteenth century was Sanitas, a non-toxic preparation comprising turpentine, camphor and camphoric acids.⁸³⁶ It appeared on the

market in 1880.⁸³⁷ The product was advertised heavily in newspapers, journals and specialist publications, and this became more obvious as the decades progressed. The manufacturers also undertook research on its qualities, and debated this in journals.⁸³⁸ There were various branded products which contained coal tar derivatives. Jeyes, a crude creolin-based emulsion, was on the market from 1879.⁸³⁹ Jeyes was marketed as efficient, relatively non-toxic and non-offensive.⁸⁴⁰ Another high-profile coal tar preparation was Izal, marketed from 1892.⁸⁴¹ It was hailed as an effective germicide and was said to be non-poisonous and pleasant.⁸⁴² Both products were advertised in various publications, including *The Times*.⁸⁴³ The germicidal efficacy of Sanitas and the other products, was, however, a point of debate.⁸⁴⁴ Other disinfectant products were also increasingly advertised, so that by the 1890s consumers, including the working classes, were likely to encounter disinfectant advertisements.⁸⁴⁵ There was also an increasing specialisation of products; by 1900 there were several sub-categories of soap advertised, including carbolic and disinfectant soap.⁸⁴⁶ Companies also produced advice texts which promoted their products by slotting them into detailed disinfection advice similar to that in popular advice texts.⁸⁴⁷ This increase in advertising tied into wider themes. By using striking visual devices which embodied germs as malevolent, and emphasising their invisible, ubiquitous and dangerous nature, disinfectant advertising helped to create a cultural fear of germs.⁸⁴⁸ Anxiety was a key point in advertising, with advertisements playing on fears about disease, adulteration of products and foods, and child health.⁸⁴⁹ There was also a strong emphasis on the battle with germs; if bacteria were killed then the people lived, but careless actions could easily reverse that.⁸⁵⁰ The products advertised solved this difficulty; disinfectants promised to eliminate germs in a scientific fashion.⁸⁵¹

Advertising was mostly aimed at women, as it was thought that they chose the

products.⁸⁵² This was not reflected in local authority propaganda, which was aimed at a mixed gender or male audience as it appeared in newspapers or posters. Local authority publicity also differed in approach. It was text-based, and less visually appealing than commercial advertising.⁸⁵³ It also focussed on detailed instructions about avoiding disease, how to get help with the tasks required, and the legal penalties that could be enforced.⁸⁵⁴ This appealed to a fear of germs, but also to civic responsibility and fear of legal consequences. The differing messages of these two forms of advice are clear. Commercial disinfection was associated with cleaning and disinfectant advertisements were generally aimed at women, and promoted ongoing, generalised disinfection. Local authority advice was more comprehensive in its audience and sedate in its appeal, promoting the same types of message as printed advice books.

It is difficult to gauge how far branded disinfectants were used by the public. Most evidence is from commentators talking about working class responses, and there is little direct comment from this group. The increased marketing can be taken as evidence that the market was growing. This is difficult to verify against sales data, as there is little extant for disinfectant preparations in this period. Some data for Izal are, however, available. They show a significant upward trend in sales of 4oz. and 8oz. bottles between 1897 and 1913 although the sale of larger bottles remained static. This could show that the demand was not from local authorities, but from domestic sources. This information would seem to indicate an increasingly positive market for these disinfectants, although its overall size was small. There is also evidence of the use of disinfectants within the home. Testimony from a woman born in the early twentieth century highlighted how she was expected to scrub the floor with disinfectant soap, as it reduced the numbers of insects.⁸⁵⁵ The Manchester Ladies Health Society sold carbolic soap for 2d/lb or 5d/3lb bar, with some given free to the poorest. They also gave out disinfectant powder and explained its use.⁸⁵⁶ Oral histories also show that carbolic soap was used for domestic cleaning.⁸⁵⁷ Whilst direct evidence on working class behaviour is rare, it suggests that using disinfectant soap for day-to-day cleaning was common.

There are also middle class statements about the popularity of commercial

disinfectants. Most commentators agreed that carbolic acid and chloride of lime were popular from the late 1870s onwards.⁸⁵⁸ Others approached these disinfectants in a way that made it obvious that they would be familiar to the public.⁸⁵⁹ Other disinfectants frequently recommended and seen as in common use were Condly's Fluid, Burnett's fluid, and, from the 1880s onwards, the new commercial disinfectants such as Sanitas.⁸⁶⁰ There is evidence that these substances were not widely used. In 1900 *The Chemist and Druggist* indicated that new disinfectants were not necessarily popular as they "hoped that ... non-toxic disinfectants ... would become common and popular items of public consumption".⁸⁶¹ By 1909, however, Rideal claimed the disinfectant market was "enormous".⁸⁶² Whilst the picture is fragmentary and mostly comprised of middle-class professional views, it seems likely that public use of disinfectants was increasing from the 1870s onwards, albeit more commonly among the middle classes who could afford to buy commercial disinfectants.

This trend fits into wider changes in patterns of personal hygiene and cleanliness. Many historians have stressed the extent to which middle-class values and standards of domesticity were increasingly communicated to and imposed on the working classes in the latter half of the nineteenth century, although this process was not always successful.⁸⁶³ Working class preferences and desires played a role, as did practical limitations before local amenities such as public baths were available.⁸⁶⁴ From the 1880s onwards the sanitary movement increasingly concentrated on women's behaviour and education, and used middle-class women to transmit messages about cleanliness, hygiene and domestic management to working-class women.⁸⁶⁵ Kelley has shown that these ideals of domesticity demanded that the home should be clean, orderly and healthy; this was also reflected in practice for at least some sections of the working class.⁸⁶⁶ These ideas, whilst not necessarily aimed at cultivating disinfection *per se*, acted to promote processes which were seen as linked to disinfection. Tones has also pointed out how disinfection could be 'imagined in relation to and in terms of existing household practices', and neatly

fitted into this model of desirable domesticity.⁸⁶⁷ There is also some evidence of increasing awareness of germs. Beier has described several cases where a nebulous fear of “germs” led to people being concerned about contact with possibly infected persons or objects.⁸⁶⁸ There is some evidence that this was having an effect on working-class behaviour and was reducing disease, although this was by no means a universal effort.⁸⁶⁹ These accounts also show how many working-class women made supreme efforts to maintain cleanliness in their homes, and there are also clear examples of domestic neglect.⁸⁷⁰ Working class women faced significant problems in achieving cleanliness, due to the poor condition of housing, overcrowding, and structural factors such as a lack of running water.⁸⁷¹ Disinfection should therefore be viewed in the context of these other changes in attitudes, but the limits of this trend must be remembered.

There is also evidence of direct neglect of disinfection, especially in the early decades of disinfection practice. Hardy has argued that citizens often refused to disinfect or falsely claimed it had been done.⁸⁷² This is backed up by contemporary comment. Timins claimed that it was “truly lamentable” to see the suffering caused by the neglect of disease prevention.⁸⁷³ Russell, writing ten years later, claimed that the public were not scared enough of diseases and thus became complacent, avoiding effective disease prevention measures, including isolation and disinfection.⁸⁷⁴ There are examples from the case studies of poor practice. In 1888 a case emerged in Liverpool where the relatives of a typhus patient continued to use the patient’s bedding. The inspector, calling round the next day to collect it for disinfection, found them sleeping on the bed contrary to orders.⁸⁷⁵ There were also concerns in Bolton about the neglect of disinfection after typhoid.⁸⁷⁶ In Manchester the authority found that tenants had refused to carry out disinfection for tuberculosis.⁸⁷⁷ Manchester also found that tenants were unwilling to allow their bedding to be taken to be disinfected, so the authority had to accept the householders boiling the bedding themselves.⁸⁷⁸ This was not confined to the areas examined in this

study. Beier has pointed to hints of resistance to disinfection in Preston and Lancaster. The Lancaster example, however, showed that the authority was usually able to prevail in disinfecting the room, the bed and bedding, and everything in the sick room; where they fell down was in getting parents to hand over clothing, especially Sunday best.⁸⁷⁹ The differential value and use of items acted to make the desirability of disinfection stronger for some items rather than others.

Middle class commentators claimed that neglect of disinfection stemmed from several causes. Ignorance of the need for disinfection was a key problem, and one which many authors thought could cause the spread of infection.⁸⁸⁰ Indeed, historians have identified that this was not confined to the working class.⁸⁸¹ Truman and Sykes, writing in 1896, thought it was “a great pity that the general public, either through carelessness or ignorance, will not recognise the great importance of disinfection”.⁸⁸² Idleness was also a concern for many commentators.⁸⁸³ Whilst some of these comments may have been exaggerated and ignored structural factors, such as the lack of domiciliary water supplies in many homes, they provide a useful counterpoint to the positive picture outlined above.⁸⁸⁴ This can be highlighted further by examining wider working-class attitudes to healthcare. Beier has shown that working-class families could deliberately expose children to diseases “to get them over with”, or refuse to notify or ignore home isolation measures as they interfered with the running of the household.⁸⁸⁵ Working class women were also thought to be resistant to learning proper isolation protocols.⁸⁸⁶ Whatever the cause, it is clear that it was thought that the wave of enthusiasm for disinfection was not universal.

Education and compulsion: Professional approaches to managing popular attitudes

How did the professions approach the issue of public disinfection? Professionals recognised that they needed public co-operation otherwise their systems would not work.⁸⁸⁷ There were specific circumstances where their role was most obvious. Householders could refuse to accept isolation, or, as was common in the case studies examined,

isolation facilities might be inadequate. This meant that some cases would be nursed at home, and sick room management, even where utilising the maximum of local authority help, required the ongoing input of the householder and his family in disinfecting excreta, clothes, bedding and utensils during the course of the illness, as well as maintaining strict rules of isolation and patient care. The public thus needed to be conversant with disinfection practice and willing to undertake it themselves. Indeed, most advice texts written by medical professionals and public health commentators assumed that the public needed to understand the processes of disinfection used within and outside the home, and explained them in some detail. This was aimed at improving the specific practices of home disinfection. A more enlightened public opinion could also further enhance disinfection practice in non-epidemic circumstances by promoting use of disinfectants, cleanliness and general attention to hygiene, as well as increasing public willingness to listen to advice.⁸⁸⁸ Public views of disinfection, and germ theory more generally, were thus very important.

Professionals were, however, very concerned about the choices the public made when involving themselves in disinfection. The commercialisation of disinfection and positive public response to such preparations provoked particular concern. The recommendation of apparently useless disinfectants was a source of concern in the second half of the century. Authors dismissed popular disinfectants as “parlour disinfectants”, “useless“, “placebos”, “a mockery to those who do know [about disinfection] and a mischievous delusion to those who do not”, and “rubbish”, whilst the more restrained critics commented that the composition of many commercial disinfectants was unknown and thus their effectiveness was unverified.⁸⁸⁹ These delusions about the effectiveness of popular preparations were damaging and demanded explanation.

Many commentators attributed this to the wily ways of manufacturers, and the role of advertising in creating public demand was heavily criticised. Marketing methods were seen as “dubious at best”.⁸⁹⁰ Other authors claimed that advertisers knew the extent of public ignorance and acted on it.⁸⁹¹ This statement seems unfair; the success of

unscrupulous advertisers owed as much to increases in public attention to public health as to their ignorance on the specifics. Nevertheless, the public were supposed firmly to believe that the “dubious disinfectant advertisements reflected actually effective preparations” and therefore most of the disinfection they undertook was ineffective.⁸⁹²

This could be linked to the sheer range of choices of disinfectants; as the number of disinfectant substances grew, the public were increasingly unable to distinguish between the good and the bad, and thus tended to rely on those which were strikingly advertised.

⁸⁹³ This criticism of advertising technique is interesting. Tomes has pointed to the use of advertising as a way to spread the “gospel of germs” in the USA, and British disinfectant companies produced educational materials which aimed to inculcate correct behaviours as well as sell products.⁸⁹⁴ Whilst the methods might have sometimes been used for good, the ability of advertising to manipulate the public was regarded as suspicious.

Many advertisements after 1903 adopted the language of science, innovation and disinfectant standardisation, deploying concepts such as the “carbolic coefficient” to bolster the appeal of their products.⁸⁹⁵ Indeed, the use of a neutral “expert”, often a scientist or a doctor, was a common feature in advertising, as was the use of facts and

statistics to add weight to the claims made.⁸⁹⁶ Such techniques came in for particular criticism, with authors warning that the public was utterly deceived by these “pseudo-scientific certificates”.⁸⁹⁷ Nevertheless, whilst professionals were eager to claim that

control of scientific language and evidence should lie with them, they did not have a suitable way to assert this as there was no agreement on how to assess disinfectant effectiveness. Loeb has shown that advertisements for influenza preventatives used the same language as medical advice; whilst medical professionals read this as an affront to their training, in practice their ability to command a specialised language and knowledge was limited.⁸⁹⁸

Reality lagged behind the self-perceived professional identity of medical men and bacteriologists. These commercial influences apparently meant that it was manufacturers, rather than MOsH or disinfection experts, who directed how disinfectants were used.⁸⁹⁹ Concerns about professional reputation are clear in these discussions;

manufacturers, with the aid of “science“, were usurping the power of MOsH and medical practitioners. Given that professional incomes were dependant on the ability to persuade society more widely that their specialist services had value, and were exclusive to them, the advertising of popular disinfectants could also undermine medical incomes by decreasing medical practitioners’ role in providing advice on managing disease.⁹⁰⁰

The actions of MOsH also came in for criticism. T. Naylor claimed that whilst the man in the street thought that MOsH controlled disinfection, it was actually directed by the disinfectant companies.⁹⁰¹ MOsH were too weak to challenge this hegemony. Their inability or unwillingness to confront public opinion was more explicitly critiqued by other commentators. A medical practitioner, writing in 1907, stated that public authorities were often extremely remiss in their approach as they used commonly accepted placebos rather than radical disinfectants. They did this in deference to ignorant public prejudice, as such a course cost less time and money and did not provoke criticism as the products did not damage property.⁹⁰² The public was also believed to demand popular disinfectants from MOsH, as they thought, based on advertising, they were effective.⁹⁰³ MOsH had little faith in public disinfection so gave into their wishes.⁹⁰⁴ The role of the “ignorant public” and their preoccupation with their property was regarded as a serious impediment to disinfection.

The dangers of this misplaced authority could apparently not be overrated, and were twofold. According to many commentators public trust in ineffective disinfectants meant that they were lulled into a false sense of security.⁹⁰⁵ This was a risk to individual and public health. The second complaint was that such purchases were expensive, which many sections of the public could ill afford.⁹⁰⁶ Commercial disinfectants were a dangerous waste of resources. Indeed, the ineffectiveness of popular disinfectants left the public disappointed, and made disinfection generally seem like a quack remedy.⁹⁰⁷ Commercialisation therefore struck at the heart of disinfection, and undermined the public’s ability to be helpful.

These criticisms of commercial disinfectants linked into a wider debate: could the

public be relied upon to undertake effective disinfection at all? The verdict was generally negative. There was a consensus among medical professionals that the public was poorly informed about disease prevention. Dr. Alfred thought that people were very ignorant about the nature of the *materies morbi*, and that there was a “hopeless fog” in their minds as to the differences between antiseptics, disinfectants and deodorants and their correct uses of agents, meaning that public efforts did more harm than good.⁹⁰⁸ T. W. Naylor rather despairingly stated that “the man in the street thought that you just have to show a microbe a disinfectant and it would immediately succumb”.⁹⁰⁹ The idea that public efforts at disinfection were always incomplete, and therefore useless, was repeated throughout the later nineteenth century and in the local case studies.⁹¹⁰ There was also concern about situations in which the public would have to maintain disinfection for a prolonged period, in particular, in the management of tuberculosis. Arthur Newsholme (future Chief MOH of the LGB) thought that disinfection instructions were often neglected, dropped, not given or not followed.⁹¹¹ Leaving any part of the disinfection process to the public was thus contentious.⁹¹² Interestingly, these criticisms started before changes in disinfectant testing methods were well established, showing that this was a wide-ranging uncertainty over public practice. These concerns also linked to wider problems with products such as patent medicines. Vincent has pointed out that the educated classes were often confused about the effectiveness of patent medicines, and claimed that those not educated beyond the basics “could not be expected to reconcile the conflicts” these preparations provoked.⁹¹³ In this way ignorance was not a product of a lack of education, although it could be exacerbated by it. Public involvement in disinfection was both necessary, and liable to be problematic.

There were several suggested solutions to these problems. The first approach, accepted throughout the period, was that disinfection should be removed from public hands, as far as possible, and made the responsibility of the local authority. This was highlighted in many texts.⁹¹⁴ An article in 1888 reckoned that in order to be effective, disinfection had to be undertaken by the authority for the people, not by the people.⁹¹⁵

This could be coupled with a push for isolation, as if most cases were removed to the hospital the authority would be able to control all aspects of disinfection. This placed the decision-making with the MOH, which could be problematic in practice, as we shall see in the next chapter.⁹¹⁶ Objectors, however, believed that the slightly penal nature of this approach would lead to people seeking help from quacks.⁹¹⁷ The behaviour of some authorities enhanced this spectre of enforced disinfection. Halliday has shown that some areas would threaten households with fumigation if they failed to use the free disinfectants handed out.⁹¹⁸ This would have done little to improve perceptions of disinfection.

The second recommendation was for education. Many authors thought that the public should be taught that disinfection was equal to the killing of disease germs, and that this was not easy.⁹¹⁹ For example, Rideal claimed that “we must cease to be misled by laudatory advertisements and antiquated opinions founded on inaccurate experiments before bacteriology became a science”.⁹²⁰ This education was to come from local authorities and recommended texts to ensure that it was accurate, although as we have seen this did not always happen in practice.⁹²¹ The third recommendation was for control of disinfectants and advertising, either by manufacturers’ guarantees or by government legislation which would allow their efficacy to be checked.⁹²² Others went further, calling for legislation to end dubious advertising and thus protect the public interest.⁹²³ There were also comments about the need for an authoritative body of independent experts to establish which disinfectants were best for which purposes.⁹²⁴ This would protect the public and local authorities from ineffective preparations and poor quality control between laboratory and practice.⁹²⁵ Whilst these methods may well have had the potential to be effective, they ignored the problem that there was no consensus on which disinfection methods were most effective and should be recommended, leaving uncertainty which could be exploited.

Although local authority disinfection was the accepted best means, there was

significant debate about how to package and approach the subject. The authorities were aware that they might face problems. One key theme that emerged in discussions of this period is the idea of the Englishman's home as his castle.⁹²⁶ Householders were unwilling to breach the privacy of their homes by allowing public health workers, with their paraphernalia and intrusive advice, to venture inside.⁹²⁷ Research on other public health policies has highlighted that MOsH and their staff were well aware of these problems, and whilst they faced concealment from the middle classes the most obvious opposition came from the working classes.⁹²⁸ Whilst opposition declined over time there was still antipathy to policies such as notification as late as the 1890s.⁹²⁹ Hardy has claimed that resolving the tension between this alliance of "rights" and antisocial personal habits with the public health agenda was essential.⁹³⁰ Financial pressures could also affect people's reactions. Hardy also points to the incentives for all classes to ignore ill health; these pressures were stronger amongst the working classes and the poor due to financial factors, meaning that cases might not come forward.⁹³¹ The potential for items to be damaged or destroyed also put financial pressure on the public, especially acute for poorer people. We could therefore expect there to be some resistance and compromise in disinfection policy.

There were discussions about how to ensure compliance with local policy. One crude way to ensure public compliance was to force them to do so.⁹³² Beier saw this as the key way in which disinfection was imposed.⁹³³ The public could incur penalties for failing to act according to the law. Several of the case studies used scare tactics. Preston warned the public of their obligations under the 1866 Sanitary Act, highlighting the fines it could impose, as did Manchester.⁹³⁴ As Hamlin has pointed out, coercion was no substitute for co-operation.⁹³⁵ As mentioned earlier, ignorance on disinfection was seen as a hindrance; education was therefore the answer.⁹³⁶ This education, contrary to that offered by popular texts and disinfectant leaflets, needed to be provided by the local

authority in order to ensure that it was being done efficiently. Education, respect and mutual benefit were key ways in which medical men and local authorities were exhorted to encourage public co-operation, and there is evidence of attempts to do this at local level. Hardy points out that part of the role of MOsH was to educate the public before pressing for controversial reforms.⁹³⁷ This could be both a courtesy, and a way to avoid opposition later on.⁹³⁸ Education was a key means of ensuring the public undertook effective disinfection within their homes, but also of gaining their co-operation. Liverpool had started public education on disinfection in the late 1840s.⁹³⁹ This was unusually early, with most other case studies following from the 1870s. This education took a number of forms. Many of the towns combined inspection with information by mandating that staff gave written or oral directions to householders on disinfection; whilst this would include exactly how agents were to be used, it also included more general information about the importance of disinfection and how the authority could help the householder to undertake disinfection.⁹⁴⁰ A lack of instructions was seen as problematic, leading to ineffective disinfection. Indeed, St. Helens was criticised for not giving detailed enough instructions when distributing disinfectants. Whether this was detrimental is unclear; a joiner, born in 1905 and interviewed in the 1970s, remembered that “when people had diphtheria, they used to come and disinfect your house. Every room had to be sealed and men from the Town Hall would pump gas into the place to kill infection”.⁹⁴¹ By this point awareness of disinfection processes had become part of local knowledge. The public also received disinfection directions from the local press.⁹⁴² Specific instructions issued during epidemics have survived from several case studies. These were along the lines of popular disinfection advice at the time, recommending hanging a sheet at the door, using carbolic acid, chloride of lime and Condy’s fluid to disinfect objects, as well as domestic methods such as boiling.⁹⁴³ These instructions remained stable over the latter half of the nineteenth century and showed little impact of new research. Public education was thus an important part of the disinfection response to outbreaks of disease, and one which aimed to provide for the effective use of

disinfectants, but it was not always consistent with the latest advice.

Practical factors were also important. There was clear emphasis on making disinfection free in order to minimise opposition.⁹⁴⁴ This was also regarded as fair, as disinfection was generally “for the benefit of the public, not the individual”.⁹⁴⁵ By offering the public a service that might otherwise have cost them money they would be enticed to co-operate. This did not, however, always work in practice. Dorothy Scannell described how “ignorant people” in her area of London in the early twentieth century turned their noses up at the free disinfectants given out by the local authority, as they regarded it as charity. They also associated disinfectants with the dirty poor, which put them off using the service.⁹⁴⁶ What was an incentive for some was a deterrent for others. Scannell’s family, however, used the handouts, although their approach was probably not what was intended. Her father used the solution, which was caustic enough to rot boots, to clean the drains and also as an antiseptic. This disinfection of drains, presumably linked to fears about sewer gas, appears in other accounts from the period.⁹⁴⁷ The provision of free disinfectants thus reached some families, but was mediated through their own perceptions of the substances’ usefulness.

Protecting the property of those undergoing disinfection was also a clear theme. Russell claimed that when applying disinfection to items of value, authorities were controlled by considerations beyond the theoretically necessary, as they needed to consider the physical effects of disinfection processes on the items.⁹⁴⁸ He claimed that the real judges of damage were housewives, upholsterers and others with direct knowledge about the items being disinfected. Laboratory tests would not be enough to convince these people of the effects of disinfection; instead, authorities should test directly on items.⁹⁴⁹ This provided a clear mandate for the consideration of practical damage and its amelioration; this was played out in relation to the common disinfection practices, as the next section shows.

Translating concern into popular advice

We have seen how there was general concern to keep the public involved in the process of disinfection, and to keep their viewpoints in mind. This shaded into concern

about how to make disinfection acceptable to the public. Practicalities thus impinged professional disinfection in specific ways. The two main foci for disinfection were, firstly, clothes and bedding, and, secondly, the disinfection of houses by fumigation and associated processes.⁹⁵⁰ As discussed in Chapter Three the methods recommended for these processes were shaped by concerns about germicidal effectiveness. They were also, however, influenced by how methods acted on different materials.

Most disinfection carried some level of damage and intrusion. Fumigation raised significant concerns. It arguably breached the privacy of the home, as it involved intrusion into a bedroom, an area which was “strictly private”.⁹⁵¹ As we have seen, legislation increasingly removed the option for householders to undertake fumigation themselves. This was reflected in increasing imposition of fumigation on the more prosperous classes, and it is clear that middle-class residents in the towns studied were expected to allow the fumigation of their houses.⁹⁵² Indeed, some contemporaries thought that the wealthy were more eager for disinfection and actively volunteered for the process.⁹⁵³ Conversely, there are examples of authorities which were concerned that people would seek disinfection even when it was not strictly necessary, showing that fumigation could be a desirable process.⁹⁵⁴ This intrusion, whilst seen by professionals as necessary, therefore had to be closely managed in order not to provoke additional concerns about damage to the room and its contents. At the most basic level, sulphur fumigation could lead to smoke damage and fires. In 1903, *Public Health* reported on a fire caused by fumigation. Despite the fact there was no hint of wrongdoing on the part of the sanitary inspector, the sheriff concluded that the impetus was on the sanitary authority to prove they did not cause it.⁹⁵⁵ Cases were also brought for negligence in fumigation where rooms were damaged.⁹⁵⁶ The sheer risk of property damage could therefore put people off.

As well as these general dangers, some fumigating agents were potentially damaging to items. Both chlorine and sulphur attacked metals, making them unsuitable for household items including mirrors and fireplaces.⁹⁵⁷ The standard advice was

therefore to remove all such objects from the room, and where this was not possible, to grease them.⁹⁵⁸ The compatibility of textiles and chemical fumigation was another area of debate. Both sulphur and chlorine could rot and bleach most fabrics.⁹⁵⁹ Textiles were increasingly advised to be removed from rooms while fumigation took place; this was made easier as superfluous furniture and textiles were to be removed from the sick room as early as possible to avoid the infection soaking into them.⁹⁶⁰ Given that other effective methods were available to disinfect textiles this was no great problem. However, there was another approach. Some authors as late as 1908 recommended that unwashable items should be fumigated by sulphur or chlorine, well shaken, beaten and brushed, and exposed to air and sun.⁹⁶¹ New methods of fumigation also offered greater possibilities for textiles to be disinfected by fumigation. Formalin fumigation was apparently popular with the public as it did not damage even delicate fabrics.⁹⁶² It was therefore recommended for the disinfection of clothes, and could even be regarded as preferable to steam.⁹⁶³ For objects damaged by effective methods of disinfection, incomplete or diluted forms of more damaging practices could be recommended as being more acceptable overall.

This incomplete disinfection was not acceptable for all objects. As well as its contents, the components of the room itself were increasingly brought into scrutiny. These were frequently problematic. As mentioned earlier, one key post-fumigation process was stripping the wallpaper. This removed infected paper, and ensured the destruction of lingering infectious particles. Although the process had been recommended throughout the period, as ideas about the effectiveness of fumigation were increasingly questioned and the issue of infectious dust raised, the processes post-fumigation were highlighted as critical to effective disinfection.⁹⁶⁴ Ruining wallpaper was therefore a normal practice from around 1880 onwards. Most commentators, both popular and professional, accepted that this would have to occur whatever the opposition.⁹⁶⁵ There is, however, evidence of dissent. Some texts saw it as a “heroic” practice, prone to provoke opposition from the public, and best avoided if other measures, such as

revaccination for smallpox, could be used instead.⁹⁶⁶ There were also concerns about disinfection as undertaken by the public and advised by their private medical practitioners. Legislation which allowed private households to arrange their own disinfection meant that these processes would be directed by individual households and could miss out difficult, damaging or dangerous stages of the process. Stripping the wallpaper might be a step too far. Queries to medical journals also highlighted that MOsH could be unhappy with the rigour of the process. The removal of paper incurred expense, which authorities were keen to avoid.⁹⁶⁷ At least some professional commentators accepted that such wide-ranging damage to property was undesirable.

Did the process actually provoke public complaint? Instances of dissent are very difficult to track down, but advice texts hinted at the problems that were thought to be faced during disinfection. Many texts and local MOsH strongly advised the public to alter their homes to fit in with the conditions that best served disinfection, or else to face the problems of replacing items, transferring the responsibility for disappointment to the disinfected themselves. One key method was to avoid the problem entirely by promoting wall coverings which could be easily disinfected. General comments against the use of wallpaper in sick rooms emerged throughout the period.⁹⁶⁸ Others suggested processes whereby wallpapers could be coated and rendered impervious to germs and washable with disinfectants.⁹⁶⁹ These suggestions were well received by *The Lancet*, although they do not seem to have progressed into widespread practice. Altering the type of wallpaper could thus only mitigate rather than solve the problem. There is also evidence that stripping and whitewashing walls was regarded as a positive process by some members of the public. Kathleen Woodward, who grew up in London in the early twentieth century, described voluntarily stripping and whitewashing the walls of her rented room to make it look more attractive.⁹⁷⁰ Whilst this may have been to do with aesthetic concerns it shows that the process was not always seen negatively.

Other, more innovative approaches were also put forward. Bread dough had been used as a way to disinfect walls in Germany, and was discussed in England.⁹⁷¹ Rubbing the walls with dough allegedly removed germs from the wall by sticking to them. Once

the process was finished the dough could be burnt and the germs obliterated.⁹⁷² If effective, the method offered disinfection that preserved wallpaper and was thus of particular attraction to those with well decorated homes. There were mixed opinions on its effectiveness. John Gay and George Newman, both informed writers with a special interest in disinfection, agreed that it was effective, although they saw it as impractical.

⁹⁷³ Not everyone agreed, however, and both Rideal and J. Rosenau doubted the process.

⁹⁷⁴ Whatever the conclusion, there were no statements that placed the method above other approaches, and it could not be recommended solely on its effectiveness in killing germs. The method was also time consuming, intensive, tedious and expensive. These

problems meant that it was not used much in practice.⁹⁷⁵ Where it was utilised it was offered as a “deluxe” service for those who were willing to pay more. For those with money the problems of municipal disinfection could be circumvented.

Another, more popular and practical, way to disinfect without destroying the wallpaper was spraying. As discussed in Chapter Three, this much-researched method had originated in France and was increasingly advocated in Britain from the late 1890s.

⁹⁷⁶ As well as often being seen as more effective than fumigation, spraying also offered a way to disinfect walls without removing the paper, reducing the objections of the householder to the loss of the wallpaper.⁹⁷⁷ Concern was, however, raised on several

occasions that wallpaper could be damaged by the method.⁹⁷⁸ Research was therefore undertaken in the 1890s by Dr. Leslie Mackenzie to ascertain the effects on wallpapers.

⁹⁷⁹ He tested the effects of formalin spraying on samples of different wallpapers. He found that formalin caused so little damage to the paper that even the supplier was unable

to tell which of the samples had been treated.⁹⁸⁰ If performed correctly, starting at the top, wetting evenly to avoid streaks, and using a fine spray, the spraying would not

damage wallpapers.⁹⁸¹ There were, however, disagreements about how this should be done. Robertson thought that spraying should start at the bottom of the wall to avoid

streaks.⁹⁸² Whilst spraying clearly had potential, there was no clear mandate on how it was to be done. These processes which protected wallpaper were not always seen as reliable and were not widely adopted.⁹⁸³ Whilst the needs of property could adjust the methods recommended and play a role in decisions, they were seldom strong enough to displace established methods. A delicate balance was needed between the needs of property, of those undertaking the disinfection, of ensuring effective disinfection.

Disinfecting Objects: Negotiating Destruction

Another key aspect of disinfection significantly affected by property considerations was heat treatment of textiles. One of the most basic ways to treat clothes was by boiling.⁹⁸⁴ This was recommended in a number of texts throughout the period as it was regarded as effective and practical.⁹⁸⁵ People were also advised that textiles put in the sickroom should be washable.⁹⁸⁶ There were, however, problems. Bulky items could obviously not be effectively boiled due to their size. Other items could not be boiled due to the effect it had on their composition.⁹⁸⁷ Woollen items were likely to shrink and change texture, rendering them useless.⁹⁸⁸ Colours could run, and items could change shape.⁹⁸⁹ Boiling also fixed stains, making items look unsightly.⁹⁹⁰ These problems drove the invention of new methods such as the Solvo process, but these did not become common.⁹⁹¹ There was also concern about the public undertaking boiling as it was thought that they would not do it effectively, and the process could not be verified.⁹⁹² This suspicion of the public was linked to concerns described in the first half of this chapter, and was a significant barrier to boiling being recommended. The process was also unsuitable for disinfecting large numbers of items at once, limiting its practicality for use by authorities during epidemics.⁹⁹³ The practical constraints of boiling and the likelihood of damage were thus a significant component of the change of recommendation to other methods from 1870 onwards.⁹⁹⁴ Chemical disinfection of clothes was also constrained by these factors. Whilst they could be germicidally effective

and offered the householder control over disinfection, chemicals were prone to stain and damage fabrics.⁹⁹⁵ This method became less commonly advised due to these problems, although recommendations continued longer in popular advice texts.⁹⁹⁶ Some commentators were particularly concerned about the implications of damage for poorer householders, and advised against the use of chemical methods.⁹⁹⁷ The physical results of chemical action was therefore concerning for those dispensing advice, although for popular texts the benefit of the householder being able to undertake disinfection themselves was an attraction.

With boiling and chemical disinfection increasingly recognised as problematic, other methods were thought to be more suitable. It was increasingly suggested that items that could not be boiled should be disinfected by dry air apparatus.⁹⁹⁸ Indeed, some popular texts approached heat disinfection as a means to prevent the need to destroy bedding.⁹⁹⁹ It was not, however, without its problems. Many commentators accepted some level of damage as inevitable in hot air disinfection in order to make it effective. Dry heat penetrated very slowly, meaning that items needed to be treated for long periods of time.¹⁰⁰⁰ This length of exposure frequently caused damage, so that items such as mattresses were significantly damaged on the outside, but still not disinfected on the inside.¹⁰⁰¹ The only way to solve this was to split the items open and disinfect the filling.¹⁰⁰² Smaller items could also be damaged, yellowed and singed if the apparatus temperature was too high.¹⁰⁰³ There was therefore clear potential for damage in hot air disinfection.

Experiments were undertaken to investigate the effects of different temperatures on items.¹⁰⁰⁴ Some of these produced positive results, stating that damage was not excessive or was reversible when moisture was re-added.¹⁰⁰⁵ Others, however, found that negative results happened regularly, increasing with length of exposure and intensity of heat.¹⁰⁰⁶ Indeed, the temperatures at which germs were killed were very similar to

those at which items were damaged, as both were organic materials.¹⁰⁰⁷ Damage was, therefore, almost an integral part of hot air disinfection above 230 degrees Fahrenheit.¹⁰⁰⁸ This did not necessarily preclude using the methods, but meant that they needed to be approached with caution.¹⁰⁰⁹ Hot air was also increasingly found to be ineffective at killing germs. Hot air was thus unsuitable in several ways but remained the main method for treating difficult items for reasons we will explore later in the chapter.¹⁰¹⁰

As we have seen, the problematic practicalities of hot air disinfection intersected with germicidal concerns, prompting a move to other methods. Steam disinfection became the main way of treating clothes, bedding and large items from the late 1880s onwards. It had distinct bacteriological advantages over dry heat, and was also much better for property.¹⁰¹¹ Steam allowed more thorough penetration of bulky items such as mattresses. This had the dual benefit of allowing unwieldy items to be subjected to disinfection, whereas before they might have been destroyed, and avoiding damage.¹⁰¹² Many authors agreed that the vast majority of items, including delicate fabrics and cheap printed cottons, were best treated by steam.¹⁰¹³ This could necessitate special arrangements. Damage to delicate or printed fabrics could be avoided by carefully controlling the steam pressure in the chamber, folding the items correctly, and removing them rapidly after disinfection.¹⁰¹⁴ These benefits were emphasised in many discussions of steam disinfection, and lack of damage was seen as a required characteristic of any equipment.¹⁰¹⁵

There were, however, still problems. Leather, silks, furs, rubber, glue and wax were ruined by minimal exposure to steam.¹⁰¹⁶ Its effect on normal textiles was also sometimes problematic, as it could fix stains, make dye run, and shrink items.¹⁰¹⁷ J. Lane Notter and H. Firth claimed that moist heat unavoidably caused the loss of the fluffiness and elasticity upon which the warmth and softness of woollen garments depended.¹⁰¹⁸ Accidental wetting within the apparatus could also produce shrinkage and

colour runs on normal items. This could be avoided by using superheated steam, but this brought with it the attendant problems of germicidal ineffectiveness.¹⁰¹⁹ This change to the appearance of items could make them off-putting and undermine public compliance with disinfection. Whilst the method was sound in theory the practicalities of steam disinfection were not always positive. Nevertheless, deciding on the specifics of saturated and superheated steam, and steam at differing pressures relied mostly on the bacteriological effectiveness of the processes. Avoiding excessive damage during disinfection was important, as was the practicality of where these methods could be applied, but effectiveness was a key concern. Where disinfecting options were equal, therefore, the least destructive one should be chosen. On the other hand, where there was no effective and undamaging option decisions could become more problematic, as the next section shows.

Difficult items: disinfecting the “undisinfectable”.

As we have seen, applying the least damaging type of disinfection was regarded as the best compromise in normal circumstances. As time progressed, however, the range of objects which were within the remit of disinfection was extended and some things were found to be damaged by common disinfection methods. Negotiating disinfection of these objects was therefore a careful balancing act, and one which was not always resolved.

Several categories of items proved particularly problematic for disinfection; this was usually because their materials were incompatible with common methods. Leathers, feathers and furs posed a particular challenge as they were damaged by most, if not all, disinfection methods. Both steam and chemicals made leather brittle and discoloured.

¹⁰²⁰ Furs and feathers were also rendered hard and dry by steam and were completely dissolved by many chemicals.¹⁰²¹ Whilst these items were not necessarily common subjects of disinfection they did have to be dealt with occasionally.¹⁰²² Suitable methods therefore had to be sought. There was a shift in the recommended methods over time. Hot air disinfection could be used on leather, fur, feathers, and books, but was not completely reliable in ensuring disinfection.¹⁰²³ Other methods, including soaking in carbolic

solution, were also mentioned, but were unreliable.¹⁰²⁴ With the advent of new disinfectants in the late 1890s there was a new way to treat these delicate items. It was increasingly regarded as preferable to repeatedly spray or wipe items with corrosive sublimate or formalin and allow them to dry.¹⁰²⁵ The addition of formaldehyde could also make hot air more effective.¹⁰²⁶ These methods were not, however, successful in either effectiveness or practicality, and other approaches were resorted to.

In some cases destruction was recommended as the only possible option. This proved to be the key point in an 1894 legal action against the Vestry of St. George's Parish, London.¹⁰²⁷ The Vestry had steam disinfected a coat, but this had ruined the leather pockets. The judge ruled in favour of the coat's owner, claiming that it was *prima facie* negligence as the coat was received in good condition and returned damaged. However, given that the only alternative would have been to destroy the coat, the case was rather pointless.¹⁰²⁸ Indeed, destruction was an option which was recommended throughout the period.¹⁰²⁹ The difficulty of disinfecting items was an impetus for destruction.

The disinfection of books also provides another interesting illustration in the changing problems of disinfecting "luxury" property. Books had not initially been seen as within the remit of disinfection; however, as time progressed and the range of objects included was drawn increasingly wide, then they became something of a problem for disinfection. At the most basic level, the proximity of books to the patient meant that they needed to be disinfected. Books were usually closely handled by the patient and had plenty of opportunity to be contaminated by stray germs. This was recognised by various commentators who included books within the objects to be disinfected.¹⁰³⁰ Cases of infection by books were also discussed. In 1893-4 *Public Health* reported on a case in St. Helens, where a book which had been kept near a smallpox patient caused a second case four weeks later.¹⁰³¹ Others highlighted that whilst any practical instances in which books had actually transmitted disease were not proven, such transmission was probable

as bacteria could hide in books.¹⁰³² There were, however, doubts about whether books actually retained infection: if they were not a danger then they did not need thorough disinfection.¹⁰³³ Although a debatable source of infection books were still seen as requiring disinfection.

There was also an increase in the perceived danger of books over time due to a number of separate factors which made them more readily encountered in houses which needed to be disinfected. Initially, some commentators suggested that books would not be a problem as the type of households that were usually disinfected would not have them.¹⁰³⁴ This comment, made in 1900, indicated that some public health workers assumed that middle class or even the upper levels of the working class would not be subject to disinfection. Even so, this did not remove the problem for more affluent households undertaking private disinfection. The householder and their medical practitioner would still have to decide on what to do with contaminated books. This class-based statement also ignored underlying developments in which households encountered municipal disinfection. Notification brought increasing numbers of more affluent families into contact with public health processes. The 1890 Infectious Diseases Act also shifted the balance of control to the authority, allowing them to compel disinfection in middle-class homes. At the same time, rising living standards meant that cheaper editions could be encountered in a wider range of homes.¹⁰³⁵ This should not, however, be over-emphasised, as books remained relatively expensive into the twentieth century.¹⁰³⁶

The availability of books from other sources also added to these problems. It was increasingly recognised that there were other locations where disinfection of books was of crucial importance. As the working classes increasingly participated in activities such as borrowing library books the potential in finding books in a home needing disinfection increased.¹⁰³⁷ The issue was raised, and several schemes to alert libraries to notified cases of disease were suggested.¹⁰³⁸ Disinfection was also seen as a way to lessen the “distaste and fear many cleanly and sensitive people” had in handling books from a library.¹⁰³⁹ The disinfection of library books was therefore an increasing concern.

Schoolbooks also became more important towards the end of the period.¹⁰⁴⁰ The advent of compulsory schooling from the 1880s onwards changed the way in which childhood diseases were spread and added a new location for infection control.¹⁰⁴¹ Schools also used books, meaning that increased numbers would need disinfection.¹⁰⁴² The need to disinfect books therefore remained a problem for local authorities.

Finding a method to disinfect books was, however, intensely problematic. Books were generally bound in leather, or held together with glue, and contained paper with ink that could run; they therefore combined several of the most troublesome substances to disinfect. How to disinfect books was therefore a significant practical problem to which various solutions were proposed. Many commentators suggested avoiding the problem in the first place by stopping books going into the sick room, or only allowing cheaper, disposable books to be used.¹⁰⁴³ Reusing the books for specific purposes was also mooted. Some enterprising commentators recommended infected library books should be given to the relevant disease wing of the local isolation hospital, avoiding the need to disinfect them.¹⁰⁴⁴ This solution does not, however, seem to have been practised with any regularity, and avoidance was not a solution for all cases.¹⁰⁴⁵

Others continued to recommend methods of disinfection to attempt to treat books. Steam was advocated by several commentators.¹⁰⁴⁶ However, steam did not always kill spores on books reliably and would thus not necessarily render them “safe”.¹⁰⁴⁷ Steam and moist heat was also found to damage the leather covers and the binding of the books.¹⁰⁴⁸ Expensive books could potentially be steamed and rebound; a costly process which was clearly envisaged as a rare occurrence.¹⁰⁴⁹ Steam disinfection was rejected due to the damage it caused. Several suggestions were made from 1888 onwards to get round this. Chemical disinfectants were a clear alternative to steam, and were suggested from time to time. Sulphur fumigation was recommended by some in the 1880s and 1890s but was displaced as concerns about its effectiveness grew.¹⁰⁵⁰ Formaldehyde was therefore

suggested. Some authors were positive about its effects, especially on bound books, and it was adopted by some local areas.¹⁰⁵¹ Valuable books nevertheless needed to be treated repeatedly and to be opened to allow the chemical access to the pages.¹⁰⁵² There were also significant concerns about its effectiveness.¹⁰⁵³ Other possible methods included alcohol or corrosive sublimate fumes.¹⁰⁵⁴ These methods left the books disinfected and undamaged, a significant advantage over other approaches. If used under vacuum conditions, apparatus could be adapted for use on large numbers of books.¹⁰⁵⁵ The arrangement of pages was a theme throughout most chemical methods, as the pages needed to be opened up to allow the chemicals access to germs.¹⁰⁵⁶ This was a time-consuming process which made disinfecting books hard, and the uncertainty meant that such methods were frequently only used for “lightly infected” books.¹⁰⁵⁷ The idea of natural disinfectants was also mooted. Sunlight could also be used in some cases, but was not generally regarded as reliable enough.¹⁰⁵⁸ Many methods were rejected due to ineffectiveness or damage. Some glimmer of hope appeared in the form of dry heat disinfection. This had been recommended in some texts from the 1870s, and continued to be mentioned occasionally up to the end of the period.¹⁰⁵⁹ It apparently offered a reliable method which only caused minor damage to books.¹⁰⁶⁰ There was, however, concern that the method was not effective, and it did not fulfil all the requirements.

Where other methods failed more extreme approaches were adopted. Books, especially cheap ones, could simply be destroyed.¹⁰⁶¹ This continued throughout the period and was the most common response to the problem. The lack of a convenient and bacteriologically sound method of treating books therefore caused problems for a disinfection agenda that increasingly sought to deal with all potential threats. As no method offered an effective and non-destructive solution there was a tendency to fall back on destruction, as it at least ensured the germs were killed. Most of the local case studies used destruction to deal with infected books, and usually paid compensation for

them.¹⁰⁶² The response to books shows that where ingenuity failed, even expensive property had to be destroyed.

Destruction: establishing the limits of acceptability

The debates about the disinfection of books tended to return to the issue of destruction as the method of last resort. This linked to wider debates about the ultimate point of disinfection. As discussed in Chapters Two and Three disinfection theory saw disinfection as the destruction of infection. Would it not be easiest to destroy infected items thus avoiding the potential for reused items to spread disease? This built on centuries of disease prevention measures that had regarded destruction as the foremost and most easily safeguarded method of restraining infection. The problem could, quite simply, be made to disappear completely. In deciding on the extent of practical disinfection the issue of destruction was therefore important. How far was destruction regarded as disinfection, and could it actually be used? This section examines the ways in which destruction was discussed as a process of disinfection, and what this can tell us about the status of property.

The legitimacy of destruction as the most basic disinfection process was highlighted in the nineteenth century in a number of ways. Fire was often cited in an abstract sense as the most effective and ancient disinfectant process, appearing in both professional and popular texts.¹⁰⁶³ Some of these recommendations were academic, describing it as a process previously practised but no longer relevant.¹⁰⁶⁴ Destruction could, however, be seen as necessary in contemporary disinfection. The way these recommendations were structured is interesting. Some authors saw destruction as the most appropriate for diseases, such as smallpox and cholera, which were regarded as particularly difficult to kill.¹⁰⁶⁵ The necessity of destruction was also linked to the uncertainty concerning certain diseases. For instance E. Hart claimed that clothes infected by smallpox, plague, scarlet fever and some other diseases should be burnt.¹⁰⁶⁶ This was because other methods contained an element of doubt which meant that unless they were pursued past the point where items were damaged or destroyed people could not be certain that their action had been secure.¹⁰⁶⁷ This idea that certainty could not be

achieved unless the item was destroyed was repeated by other commentators in the 1880s.¹⁰⁶⁸ Some texts therefore erred on the side of caution and recommended the destruction of a large number of items.¹⁰⁶⁹ Gay, for instance, recommended that anything “that could be” destroyed should be.¹⁰⁷⁰ Other authors recommended destruction as the best option but accepted that other approaches were suitable alternatives in some cases.¹⁰⁷¹ Destruction was also a method of last resort where others were not available.¹⁰⁷² This was of particular relevance for the hard-to-disinfect items, already mentioned, but also toys, letters and papers.¹⁰⁷³

Destruction was also recommended throughout the period for items of little value.¹⁰⁷⁴ Items which were worn out, soiled or otherwise undesirable were prime targets for destruction.¹⁰⁷⁵ One main category of low value items which needed to be destroyed was handkerchiefs, rags and dressings. Advice texts, both popular and professional, and local authorities advised that these items should be routinely destroyed.¹⁰⁷⁶ To reduce costs, rags were recommended instead of handkerchiefs.¹⁰⁷⁷ The value of the property was important in determining whether it should be destroyed.¹⁰⁷⁸ These items also demonstrate a separate focus on destruction for items soiled with discharges. Bodily discharges were regarded as full of germs, and as difficult to disinfect due to the large amounts of organic material that could envelop and protect the germs. It is within this context that some authors recommended that only heavily soiled items should be destroyed.¹⁰⁷⁹ The destruction of rags and dressings was therefore uncomplicated and easily agreed on, despite the fact that they could probably have been disinfected. Destruction was structured according to the uncertainty of disinfection, the expense of the item and how soiled the items were.

Practical experience also supported destruction policies. The ability of authorities to destroy items as they saw fit was included in the 1875 Public Health Act.¹⁰⁸⁰ The

authorities were able, if they wished, to give compensation.¹⁰⁸¹ The provision for compensation demonstrates the perceived need to allay fears regarding property. This was, however, only optional: compulsory compensation clauses were then included in the 1890 Infectious Diseases Act, although this did not solve all the problems.¹⁰⁸² The issue of whether damage was, as the Act described it, “necessary or unavoidable” was a key flashpoint as this controlled whether compensation was paid.¹⁰⁸³ Indeed, Brighton adopted the Act with the expectation that it would indemnify them against further compensation claims.¹⁰⁸⁴ Most items which were destroyed would be those belonging to the working class, as it concentrated on low value or soiled and dirty items.¹⁰⁸⁵ Destruction, and compensation, was thus likely to be a classed phenomenon.¹⁰⁸⁶ Indeed, some recognised that poorer people were less able to cope with the removal of items and would be more concerned about it.¹⁰⁸⁷ As Beier has argued, the destruction of still useful possessions “must have seemed terribly wasteful”, and replacing them would have been a financial burden.¹⁰⁸⁸ Nevertheless, she also highlights evidence that neighbours and relatives would give patients worn out clothing that could be destroyed. This shows awareness of the dangers of infected clothing, and of destruction policies.¹⁰⁸⁹ This could also be seen to demonstrate acceptance of destruction policies and concern about the practical dangers of soiled items; compensation would remove some of the sting of the loss of items.

Compensation for the poor was a way to ensure compliance with disinfection more generally. It could, however, also be regarded as problematic. Liverpool initially gave out monetary compensation. Whilst this system was in place from 1875 to the 1890s, it seems that by this point there was significant concern that the money was spent on drink instead of replacement items. A reputable firm was thus used to provide replacements.¹⁰⁹⁰ Compensation therefore needed to be approached carefully, lest the public abuse it. Other authorities were keen to avoid compensation wherever possible.

Brighton actively avoided liability for compensation.¹⁰⁹¹ An article in the *British Medical Journal* in 1881 also claimed that the compensation sections of the Act were “never used”.¹⁰⁹² Willingness to pay compensation thus varied significantly between authorities.

MOsH pursued destruction policies of various intensities. Some were rather dramatic. An outbreak of typhus in St. Saviour’s parish, London in 1879 led to the burning of all the furniture in the room, stripping the walls and fumigation.¹⁰⁹³ Burning was advocated for some larger items by other MOsH with practical experience.¹⁰⁹⁴ Some authorities could decide to destroy items rather than to disinfect, as they believed it was cheaper and more effectual than maintaining a disinfecting apparatus.¹⁰⁹⁵ The evidence from the local case studies also shows the extent to which these tensions were worked out in practice. Data and comments from these towns illustrates the practice and the rationale behind it.¹⁰⁹⁶ The first important point is that destruction was deployed for many items that could have been disinfected. In both Bolton and Manchester, clothes and bedding were routinely destroyed. Liverpool destroyed an average of 1,500 articles a year, and disinfected an average of over 30,000 in the same period. Manchester disinfected 4,157 items of textiles in one quarter of 1898, and destroyed 11 items.¹⁰⁹⁷ There were several reasons for destruction. Serious disease outbreaks were unsettling enough to provoke destruction rather than disinfection.¹⁰⁹⁸ The condition of items, however, was a more common cause for destruction. Worn, dirty, or otherwise unpleasant items were targets for destruction, as it “was not worth” disinfecting them.¹⁰⁹⁹ Local authorities were making judgements about the value of items which would not necessarily be the same as the opinions of their owners, and which would make the household goods of the poor more likely to be confiscated. Destruction was thus a resort for a minority of items but affected a numerically important proportion of infected families, and was almost certainly biased towards poorer sections of the community.¹¹⁰⁰ Another key point which emerges is the idea that the public was willing to co-operate, or

even to volunteer, for destruction of items in some instances. The Bolton MOH included a category for “articles of bedding and clothing destroyed at owner’s request” within his results.¹¹⁰¹ This may well reflect a desire on the part of the authorities to legitimise the destruction of property, but it does also indicate perhaps that these services were accepted and used by the population at large with at least some veneer of voluntary response. The level of compensation provided usually allowed for the purchase of a new item, or, in some cases, provided a new item directly; this might have been desirable for some people. Perhaps the promise of compensation was enough to attract positive engagement. Destruction was more commonly used in practice than in recommendation.

Nevertheless, despite these policies and the evident usefulness of destruction, fire as a disinfectant was dismissed as impractical for the vast majority of objects.¹¹⁰² It was simply impractical, in the most part, to routinely destroy large numbers of items, especially if those items had any value.¹¹⁰³ Indeed, several authors recommended that items with any value should not be destroyed due to the expense of replacing them.¹¹⁰⁴ Statements condemning the destruction of large numbers of items appeared in some texts.¹¹⁰⁵ As confidence in other methods increased and bacteriological testing offered the possibility of evaluating disinfection more closely, the need for destruction due to uncertainty over disinfectant effectiveness retreated. Whilst destruction remained popular in practice, it was a declining strand of advice. Other authors highlighted the practical problems of actually undertaking destruction. E. Seaton claimed that burning as a method of disinfection was much less commonly used than might have been desired as it was actually quite difficult to get things to burn thoroughly. Better means of destruction therefore needed to be sought if the method was to be used.¹¹⁰⁶ Some commentators even questioned whether it was strictly “true disinfection” or should be regarded as a totally different process.¹¹⁰⁷ The practice of destruction was regarded by some as evidence of a lack of faith in disinfection. Vacher claimed that authorities that destroyed items rather than disinfecting them demonstrated a lack of faith in their disinfecting capability, and although it was a suitable approach from a safety point of view, it was one

which was likely to prove expensive.¹¹⁰⁸ As we have seen, destruction declined as a common recommendation.

The desirability of destruction demonstrates a number of points. It was seen as related to the worth of the article, with cheaper items and the most heavily soiled being recommended for destruction throughout the period. Finally, the difficulty of finding a suitable method of disinfection for some problematic or composite materials also prompted a move to destruction. These sets of motives demonstrate the trade-off between effectiveness, property and practicality which affected disinfection in this period.

Conclusion

Disinfection inevitably brought new chemicals, methods and techniques into the homes of the public, potentially threatening their possessions. There was significant need for the public to co-operate with municipal practices, and also to take on some of the work themselves. They were exhorted to pursue disinfection according to new “scientific” rules and guidelines, although popular advice drifted further from this than many professionals would have liked. This seems to have resulted in a new culture where disinfection combined with cleanliness and became a popular part of domestic management for some, but by no means all, sections of the public. The professions, however, were deeply ambivalent about the necessity of relying on even the educated sections of the public and were frequently dismissive about any form of “amateur” disinfection. The new “scientific” nature of disinfection limited its practice to experts, excluding lay-people of all classes. There were ongoing concerns about the propensity of the public to make poor choices of disinfectants and methods and about the ways in which public opinion was manipulated by commercial interests, and the often misleading use of scientific concepts in disinfection advertising.

The professions therefore concentrated on removing as much responsibility from the public as possible, aided by legislation that supported the role of local authorities. This increased the possibility for conflict with the public over issues such as fumigation and disinfection of objects, as most disinfection methods had the potential to be damaging. There were therefore compensating attempts to minimise the destructiveness of the processes. The example of fumigation shows that where the demands of property could not be reconciled with perceived effectiveness, effectiveness won out, whereas the

case of steam disinfection shows that where factors flowed in the same direction it was easy to adapt to the needs of property; how to deal with some objects and situations was much clearer than others. There were limits to this clarity, as approaches to destruction show. Destruction was in theory reserved for items that could not be dealt with any other way. In practice, however, a much wider range of items were subject to destruction, due to concerns about effectiveness but also the sheer practicalities faced in disinfecting soiled and damaged items which authorities perceived to be of little value. Class therefore emerges as a key factor in determining the practical experience of disinfection; whilst all sections of the public were potentially suspect in terms of their personal approach to disinfection, the working class was subject to more destructive and invasive policies. The progress of disinfection and its increasing application to a wide proportion of the population shows that the tenets of privacy and property rights were weakening over time. The increasing status of scientific knowledge meant that it could outweigh both respect for privacy on the part of preventive health authorities and the desire to maintain privacy at all costs on the part of the public. This was, nevertheless, still a balancing act. The relationship between property, the public and disinfection was one of uneasy compromise which attempted to fulfil often divergent aims, and intersected uneasily with the existing class structures and emerging professionalisation of late Victorian society.

Chapter Six: Disinfectants, Safety and the Public.

As we have seen, damage to property was a concern in disinfection at both national and local level. Other safety concerns also affected the ways in which disinfection was approached and practised. The issue of personal safety of those using disinfectants, and the use of disinfectant solutions to cause harm, including suicide, was of concern throughout the period. This chapter examines the national debate about the safety of disinfectants, linking this with the Registrar General's statistics on deaths from disinfectants, and identifying the influences of these concerns at local level. The first half of the chapter examines professional and popular advice manuals on disinfection, highlighting that safety was often mentioned as a necessary characteristic of disinfectants, and that "popular" disinfectants were marketed as safe alternatives to the more toxic preparations. Nevertheless, risk could be tolerated if the germicidal effectiveness of the

preparation was high enough. Where the safety and effectiveness pressures coincided, practices such as fumigation of occupied rooms could be abandoned and replaced with safer options, i.e. removing the patient then fumigating the room, but where the pressures were conflicting, as with chemical disinfection, there was no clear recommended path. These themes are illustrated in relation to three specific case studies which show the factors legitimising and limiting the use of poisonous disinfectants, and the parameters within which this could occur. The first example, Burnett's Fluid, shows that safety was a concern throughout the century. The second, corrosive sublimate, shows the limitations on the use of an effective disinfectant. The third example, carbolic acid, illustrates that where the recorded death toll from a chemical was large the situation could rapidly become complicated. The discussions of safety highlight the ambivalence of many medical and public health professionals towards the role of the public in disinfection: whilst distribution of effective disinfectants to the public was important for health, the tendency of the public to poison themselves with chemicals meant that there was an implicit tension between two strands of public safety in these debates.

Safety and the perfect disinfectant

Before examining the progress of specific debates about different disinfectants it is important to explore more general discussions of the safety of disinfectants. Poisons were a part of everyday life before poisonous disinfectants were introduced; disinfectants intended for use in the home, however, added to the number of poisonous substances used in a domestic context. Their specific role in protecting health also meant there was a trade-off between preventing illness and the dangers of chemicals. The nature of many nineteenth-century disinfectant preparations and processes were at best harmful to health and at worst potentially deadly.¹¹⁰⁹ Some dialogue concerning the safe use of these chemicals might therefore be expected to emerge, especially given the wider debates about the control and safe use of drugs such as opium in this period.¹¹¹⁰ This chapter addresses the issue of disinfectants intended for use on clothes, surfaces and items; this was the main way liquid disinfectants were used and was a crucial part of overall disinfection. Bodily and curative disinfection was not a mainstream disinfection pursuit after the 1870s.¹¹¹¹ It was assumed that these internal disinfectants should be as

minimally damaging as possible.¹¹¹²

The issue of safety of disinfectants was discussed in various guises throughout the nineteenth century. One key focus were discussions of the hypothetical perfect disinfectant. By the 1880s, disinfectants were not generally intended for internal use; some degree of toxicity could therefore be tolerated. Many professional authors set out a list of characteristics which the ideal disinfectant should possess and often included non-poisonous, non-toxic and non-irritant as desirable features. These comments appeared in specialist texts throughout the period from 1870 to 1900.¹¹¹³ These discussions were, however, confined to the professional texts: popular works did not discuss the ideal disinfectant, preferring to concentrate on specific advice rather than philosophical debates. It is clear that safety, both in terms of non-toxicity when ingested, and to a lesser extent in terms of damage to the skin or wounds, were serious considerations when contemplating the ideal disinfectant. Commentators did not elaborate on why these properties were necessary but, judging from the other factors often listed alongside safety it seems that safety was thought to facilitate use of the disinfectant. A potentially unsafe or poisonous disinfectant would be as difficult to use safely as would a slow acting or insoluble one, and these features would put people off using the product effectively. For authors speculating about the perfect disinfectant, therefore, “safety” as a property served a dual purpose: it would both rightly protect the health of those using the disinfectant, but would also ensure that disinfection was undertaken properly. These debates did not result from legal necessities. There were legal implications only for those substances covered by poisons legislation; any other toxic substance could be sold without warning labels or special conditions, by anyone.¹¹¹⁴ Despite some encroachment by poisons legislation, *caveat emptor* remained pretty much intact throughout the century.¹¹¹⁵ This had been a key point of debate when regulations were drawn up, as many common medicines were poisonous if misused, and both doctors and chemists were keen to avoid any widespread labelling of such drugs as “poison”, fearing it would cause widespread concern.¹¹¹⁶ This dual fear and tolerance of poison could undermine disinfection; an innocuous disinfectant was therefore desirable. At the most basic level, safety was also necessary to ensure

chemical disinfection saved more lives than it took. If disinfectants were unsafe enough to cause significant mortality then their entire purpose would be defeated, and, whilst those recommending their use would not have been liable for any consequences, it would have undermined the willingness to use disinfection.

Safety also had implications for the choice of disinfectants. Non-toxicity and harmless action on human tissues were both used as recommending factors for disinfectant solutions, as shown in many advice texts, but also in advertising for commercial disinfectants. These statements were a staple feature of both popular health guides and advertising and promotional materials.¹¹¹⁷ Professional texts advocated non-toxicity as an ideal and difficult to obtain characteristic, whilst popular and commercial materials heralded it as one which many preparations fulfilled. This can reasonably be taken to indicate that it was thought that there was a wider public preoccupation with safety, and that non-toxicity was a characteristic demanded by at least some sectors of the public. Some used this supposed concern to explain changes in the disinfectants used by the public, claiming that they had switched to non-toxic disinfectants due to fears about safety.¹¹¹⁸ Safety therefore emerges as a point of concern in determining actual disinfectant choice, as well as in theory.

There was, however, an opposing viewpoint. Whilst safety was an important feature it was often subordinated to effectiveness. Put simply, “safety” was worthless if the disinfectant was ineffective or needed to be used in large quantities. Indeed, lists of the characteristics of a perfect disinfectant always listed effectiveness, but not always safety.¹¹¹⁹ Other texts specifically subordinated safety beneath effectiveness. For example, C. G. Moor stated that whilst it was essential for a disinfectant to be effective, it was only desirable that it was non-poisonous and non-caustic, although poisons which were lethal by limited contact were unusable.¹¹²⁰ Effectiveness was the chief necessary property of a disinfectant, and safety was a second order requirement. For some professional authors an effective and non-poisonous disinfectant was just an ideal. R. Smith stated that “all disinfectants are poisonous in sufficient quantity”, and claimed that disinfectants were “safe” to use only because the amount needed to kill germs was less

than the amount that would kill an animal; if this was not the case then the worker would perish before the task was complete.¹¹²¹ For Smith, therefore, a wholly non-poisonous disinfectant was a contradiction in terms.

As bacteriological research during the 1890s showed the relative hardness of germs compared to human cells, confidence in non-poisonous disinfectants receded further.¹¹²² F. Andrewes, writing in 1903, set out a typical opinion that disinfectants intended for common use should be harmless to human tissues. Nevertheless, he also stated that it was unrealistic to expect a disinfectant to be non-poisonous, as this would certainly compromise its effectiveness.¹¹²³ Others, whilst stopping short of ruling out that a non-poisonous disinfectant could exist, were sceptical that many would be found.¹¹²⁴ It is telling that these statements were made in the most part by medical practitioners and bacteriologists whose primary concern was setting out professional standards, rather than providing popular instruction. This highlights a clear divergence in opinion between these and popular texts and non-specialist manuals. Where popular texts recommended “safe” disinfectants they also stated that these preparations were germicidally effective.¹¹²⁵ Bacteriologists, on the other hand, frequently deployed up-to-date germicidal research to dismiss the effectiveness of these preparations.¹¹²⁶ These categorisations were not absolute, and some bacteriologists were positive about some popular disinfectants, in particular those derived from coal tar, although they were also often sceptical that these substances were non-poisonous.¹¹²⁷ In this way, poison was seen by many as a very likely part of any “true” disinfectant, and safety was subordinate, within reason, to germicidal effectiveness.¹¹²⁸ This tolerance for common use of poisonous chemicals reflected a wider tendency to accept hazardous chemicals with comparatively little disquiet; arsenic, which provoked arguably the most serious poison panics of the century, was present in many common household articles until the end of the century.¹¹²⁹

These issues could, however, be simply resolved, provided that both germicidal

effectiveness and safety concerns flowed in the same direction. The debates over fumigation of occupied rooms illustrate this well. This technique had been recommended in the first three quarters of the nineteenth century as a beneficial disinfection process which could also aid the patient's recovery.¹¹³⁰ A few authors went even further, stating that disinfection was incomplete if fumigating agents were not kept in the air of the sick room all the time.¹¹³¹ Nevertheless, as time progressed there was increasing emphasis on the problems this caused. Authors of both popular and professional texts agreed that it was dangerous to the patient to fumigate an occupied sick room.¹¹³² It was also impossible to ensure thorough disinfection as, unless fumigating agents were used at dangerously high concentrations the germs would not be killed.¹¹³³ Disinfection of occupied rooms was ineffective and unsafe, meaning that most texts agreed that there was no benefit in the practice. These two factors, however, did not concur for liquid chemical disinfectants. The following sections therefore examine the debates over where the line between safety and effectiveness was drawn in relation to the three most commonly debated and used poisonous disinfectants, namely Burnett's fluid, mercury chloride and carbolic acid.

Burnett's Fluid: new disinfectants, accidental death and poison regulations.

One of the earliest liquid disinfectant substances to attract attention concerning safety was Burnett's fluid.¹¹³⁴ This was a popular disinfectant which was marketed from the 1840s onwards.¹¹³⁵ It comprised a strong solution of chloride of zinc, a caustic poison with the potential to be fatal if ingested.¹¹³⁶ The clinical effects are similar to those of drinking drain cleaner.¹¹³⁷ The relative popularisation of the use of the fluid for disinfecting in a wide range of locations could therefore be expected to result in at least some debate on the safety of the preparation.¹¹³⁸ The ways in which these debates emerged illustrates interesting points which were repeated later in the century. The debates over Burnett's fluid show that safety was a concern throughout the century, that a range of solutions was developed early on to reduce the risk posed by disinfectants, and that the use of a poisonous disinfectant did not necessarily lead to widespread problems

and restrictions on its sale.

There was initial confusion over whether the substance was actually poisonous.¹¹³⁹ Commentators gradually recognised its dangers so that by 1859 Burnett's fluid appeared in a list of common household poisons in Mrs. Beeton's *Book of Household Management*.¹¹⁴⁰ The first mention of Burnett's fluid as the cause of a death appeared in 1850; cases increased in number over the next few years.¹¹⁴¹ Some deaths were approached as unavoidable accidents.¹¹⁴² Nevertheless, other cases prompted calls for action. One of the most common recommendations was to suggest redesigning the packaging so that the fluid would not be mistaken for other medicines. There appear to have been particular similarities between the bottles used for Burnett's and milk of magnesia, leading to several deaths.¹¹⁴³ It was therefore concluded that Burnett's should be sold in distinguishable bottles.¹¹⁴⁴ From the early 1860s coroners and medical journals increasingly also recommended labelling the bottles with "poison".¹¹⁴⁵ Ad hoc recommendations were the most common approach, locating the responsibility for safety with manufacturers, retailers and users.

Concurrently, there was also a move towards limiting the sale of the product via legislative action, although little effort was put into regulating sales. There were some limited attempts to force more systematic control of the substance, for instance in 1863, when *The Lancet* called for better labelling and bottle design to be imposed on Burnett by the government due to his failure to act.¹¹⁴⁶ Legislation was the last resort when less coercive approaches had failed. Although there were not widespread calls for legislation, some considered the substance dangerous enough to merit its inclusion within proposed poison legislation.¹¹⁴⁷ The rationale was that the usual safety precautions had failed to curb deaths therefore legislative action was needed.¹¹⁴⁸ This view was not, however, universal, and some witnesses before Parliament claimed that distinguishable bottles and careful sale were sufficient.¹¹⁴⁹ They also argued that any restriction on the sale of

chloride of zinc would result in limitations on its use, which was problematic as it was a valuable and widely used disinfectant.¹¹⁵⁰ Alongside these reasons identified by contemporaries we can discern other underlying causes. Regulation of poisons and drugs was generally seen as needing to concentrate on those poisons which caused the most deaths.¹¹⁵¹ If zinc chloride did not cause, or was not acknowledged to cause large numbers of deaths then this could help to explain why such little attention was paid to its regulation. Statistics of accidents and suicides appeared in the annual Registrar General reports from the 1860s onwards, allowing deaths from various causes to be tracked.¹¹⁵² Chloride of zinc caused a maximum of five deaths per annum, and this did not increase over time.¹¹⁵³ Contemporaries also increasingly regarded poisoning by Burnett's fluid as a medical curiosity.¹¹⁵⁴ Perhaps the lack of regulation can thus be attributed to more basic reasons: the substance was simply not dangerous enough to merit attention. Victorian attitudes to safety were often lax, locating responsibility with individuals unless death tolls were high enough to attract campaigning attention.¹¹⁵⁵ The debates over the safety of Burnett's fluid represented a first step in the consideration of common disinfectant fluids as specifically dangerous to use, and reveal interesting factors which would reoccur later in the century. Poisonous disinfectants could be acceptable for public use, provided basic voluntary safety measures were put in place, but legal sanctions were only seen as necessary if the threat it posed in terms of numbers dying each year was significant enough, or the effects of the poison were horrific enough; this was especially acute given that in the 1850s, only arsenic was subject to any regulation.¹¹⁵⁶ Burnett's fluid did not fulfil these criteria, and so was not legislated against. A standard canon of voluntary safety measures was developed in the first half of the century, showing that safety concerns were not confined to the second half of the century.

Mercury Chloride: government recommendation, effectiveness and safety.

Ideas about how to deal with poisonous disinfectants developed during the latter half of the century, and can be illustrated with reference to two other high-profile poisonous substances; mercury chloride and carbolic. Mercury chloride illustrates the

way in which public opinion and safety preoccupations could effectively halt the use of a powerful germicide, even when its use was legitimised by those in high authority. Disinfectant safety was not a minority concern, and could be a significant factor in disinfectant debates. Safety and the legislation used to safeguard it could also seriously limit the use of an effective disinfectant.

Mercury chloride, also referred to as corrosive sublimate, is both toxic and caustic: this was recognised by nineteenth-century authors.¹¹⁵⁷ Consumption of the chemical causes localised tissue damage to the oesophagus and stomach, as well as systematic mercury poisoning. Tensions between germicide and safety can be illustrated with reference to the LGB's support for mercury disinfection in the 1890s. The main interest in mercury chloride as a disinfectant emerged from the 1880s, when new bacteriological research highlighting its supreme effectiveness on germs and spores made it a very attractive option for new "scientific" disinfection.¹¹⁵⁸ It had, however, been in use throughout the early part of the century for other purposes including industry and photography, and was available to the public.¹¹⁵⁹ Its characteristics made it a target for calls for regulation. Control of the substance was suggested as early as 1819, and was repeated throughout the period.¹¹⁶⁰ The frequent mention of corrosive sublimate in bills concerning poison control also indicates widespread concern over its use. The substance was then eventually included within the schedule of the 1868 Pharmacy and Poisons Act.¹¹⁶¹ This legislation set out two lists of poisons; Schedule One listed the more dangerous poisons which were subject to more stringent control. Pharmacists were to sell only to known individuals or people introduced by someone known. The name of the poison, quantity and purpose for which it was to be used, as well as the name of the purchaser and the date of sale were to be entered in a special poisons book, and signed by purchaser and dispenser. The bottle was to be labelled "poison", and also carry the name and address of the seller. Schedule Two, on the other hand, listed less active poisons. These had to be sold labelled with the chemical's name, the word "poison", and the name and address of the seller. Both schedules limited sale to licensed retailers, and imposed penalties for infringement. Mercury chloride, a Schedule One poison, was subject to

significantly tighter control than either zinc chloride or carbolic acid for most of the nineteenth century.

It is interesting to look at the number of deaths that were attributed to this cause, to assess the effectiveness of regulation. Deaths involving corrosive sublimate were reported from the 1830s onwards.¹¹⁶² The numbers of cases were low, and did not occur every year.¹¹⁶³ There were very few discussions of these cases, and they were limited to how to deal with the chemical.¹¹⁶⁴ Indeed, as it was included in the 1868 Act, there were few suggestions that could be made. Controls on mercury chloride had curbed its dangers, possibly by restricting access to it. Some recommendations were, however, made. An article in 1874 discussed a case of mercury poisoning, where the source of the poison was not found. Discussing the possibility of murder using the chemical, the author claimed that farmers and farm hands often kept large quantities of corrosive sublimate on hand to make sheep dip, (it was also used to treat syphilis), making the chemical easily available.¹¹⁶⁵ He wanted its sale to be severely limited, and called for sheep dip to be sold ready-made.¹¹⁶⁶ Its problematic nature was also discussed in some popular texts. It appeared in Mrs. Beeton's book of household management; she listed it as a principal poison, with a section on antidotes, from 1859 onwards, although it gives no indication as to why the poison might be kept in the house in the first place.¹¹⁶⁷ This shows that there was a perception that the substance would be used by some sections of the public, even if its sale was restricted.

As discussed in Chapters Three and Seven the 1880s and 1890s saw significant shifts in ideas about how disinfectants should be judged and which were effective. Mercury chloride emerged as an excellent germicide. It was found to be particularly active on even the most resistant germs and on the more tenacious spores found in diseases such as anthrax.¹¹⁶⁸ As research became more definite in the 1890s, corrosive sublimate started to be recommended in specialist advice texts with isolated instances in popular works.¹¹⁶⁹ This increasingly positive view of mercury chloride from bacteriologists and medical professionals had an impact on its wider recommendation.

LGB advice from 1888 on infectious disease specified that corrosive sublimate should be used to treat clothes and floors in the sick room.¹¹⁷⁰ Whilst there was no stated justification for why the solution was recommended, it seems likely that this was due to the prevailing research on its germicidal effectiveness.¹¹⁷¹ The LGB was clearly also aware of the problems the solution might cause, and took steps to avoid them. The chemical was to be coloured with aniline blue to avoid accidental consumption, as no other common household item or food was that colour.¹¹⁷² The coloured solution was to be treated with “proper caution”, and any articles soaked in it were to be rinsed before being sent to wash.¹¹⁷³ The LGB seems to have decided that the germicidal effectiveness of the disinfectant merited recommending its widespread use, but had recognised that its characteristics necessitated safety measures.

Some authors supported the LGB, claiming that the dangers of corrosive sublimate had been exaggerated.¹¹⁷⁴ Several drew attention to the solution’s unpleasant taste, meaning that it was unlikely to be drunk accidentally.¹¹⁷⁵ This may well have been true, but given the frequency with which substances were mistaken for each other the taste was probably of lesser importance than its appearance. Others looked at the poisonous dose. Willoughby, writing in 1893, claimed that although corrosive sublimate was reckoned to be more poisonous than carbolic it did not work this way in practice as solutions of corrosive sublimate were more dilute, meaning that the fatal dose would require much more to be drunk.¹¹⁷⁶ For these commentators, the substance was acceptable enough to recommend. Others were more wary, emphasising the deleterious nature of the solution, but accepting that the adjustments recommended by the LGB were enough to render it “safe”.¹¹⁷⁷ In the words of Rideal, choosing between corrosive sublimate and other poisonous disinfectants was simply “a matter of pro and con”, with persuasive arguments on either side.¹¹⁷⁸ It would seem that provided safety concerns had been addressed then germicidal efficacy of mercury chloride meant it was a good choice for public disinfection.

Others authors continued to highlight problems despite these safety measures. They were particularly concerned with public use of mercury chloride, counselling that the public should not be trusted to use the chemical carefully, although they conceded that in professional hands it could be useful.¹¹⁷⁹ This lingering doubt seems to have reflected the mood generally. As time wore on it was increasingly thought that the unsafe aspects of the disinfectant had affected its use.¹¹⁸⁰ Indeed, in the US by 1890, the substance was regarded as too dangerous to be marketed to the public.¹¹⁸¹ Its limited use is backed up by evidence from the local case studies, which indicate that corrosive sublimate was not used or distributed by any of the local authorities studied. It was also not mentioned in any of the Lancashire County Council MOH reports as in use in the county.¹¹⁸² It seems that despite its germicidal efficacy, increasing recommendation and LGB support, its toxic properties and the restrictions on its sale, meant that it did not become a popular disinfectant. In this way, although some professionals and the LGB had found what they believed to be an adequate trade-off between safety and use, the public and local authorities disagreed. The lack of response from the public on safety cut both ways: as well as not heeding the recommendations of coroners on the use of poisonous disinfectants such as carbolic or zinc chloride, they were unlikely to use an unsafe disinfectant even where it was sanctioned, unless encouraged to do so. There was thus clear precedent for expecting that dangerous properties, combined with regulation, would halt access to a disinfectant; this sets the backdrop for debates about carbolic acid.

Carbolic acid, suicide and safety: disinfectant safety reaches crisis point

As we have seen, by the late 1880s, commentators were familiar with the problem of safety in disinfection and had attempted to find ways to alleviate these concerns. They had also found that where a disinfectant was too dangerous and inaccessible it would not become popular. The debate that erupted in the 1890s over the safety of carbolic acid as a disinfectant built on these earlier points and highlighted several important aspects of the delicate relationship between safety, effectiveness and disinfectant use. This section examines the increasing unease about the use of carbolic acid as a popular disinfectant, showing the way in which safety concerns were fuelled by the rising death toll from

carbolic in the 1890s.

Carbolic acid, also known as phenol, is a moderately strong caustic poison, which causes skin irritation and damage to mucous membranes and other tissues if ingested.

¹¹⁸³ Its clinical effects are similar to those of Burnett's fluid, and ingesting the substance can cause a painful and lingering death.¹¹⁸⁴ Carbolic as a disinfectant achieved widespread popularity among the public and the public health hierarchy from the late 1870s onwards, so that it was the second most popular disinfectant after sulphur by 1880.¹¹⁸⁵ This was accompanied, however, by safety concerns and deaths; carbolic provides a particularly interesting illustration of the impact of safety debates.

Carbolic acid is recorded as having caused deaths from 1866 onwards.¹¹⁸⁶ As the number of cases rose, greater attention was paid to the incidents, and suggestions as to how to reduce the death toll were made.¹¹⁸⁷ One key recommendation from the start of the period and often repeated was for the better labelling and design of bottles.¹¹⁸⁸ Unlabelled bottles were implicated in a number of cases: bottles of carbolic were mistaken for other things and drunk.¹¹⁸⁹ It was therefore recommended that bottles should be marked "poison" so that the public would be aware of the danger.¹¹⁹⁰ Nevertheless, this did not remove all danger. Several articles showed cases in which carbolic had been accidentally drunk from labelled bottles.¹¹⁹¹ It was also possible for carbolic to be transferred to other containers after purchase.¹¹⁹² Other authors also commented, rather sensibly, that suicides would only be encouraged by writing "poison" on the product.¹¹⁹³ Labelling was therefore an incomplete solution to the problem.¹¹⁹⁴ Distinctive bottle design was also posited as a way to underline the message given by a "poison" label, and also to make sure that the containers were distinguishable from medicine bottles to those who were illiterate.¹¹⁹⁵ As well as the container, there were some limited suggestions about colouring and scenting the fluid to make it more recognisable.¹¹⁹⁶ This suggestion was uncommon, however; only extreme poisons

merited adjustments like colorants, which could make the substance unuseable for many disinfectant purposes. These recommendations mirrored those made by commentators talking about Burnett's fluid, and shows that the first focus in disinfectant safety was in ad-hoc solutions; it was hoped that common sense would prevail.

The carbolic debates, however, show a much greater focus on the need for legislation than any previous debate. This push towards regulation, coming as it did after the 1868 Poisons Act, initially concentrated on slotting carbolic into existing frameworks. The Act allowed extra substances to be included within either of its schedules if the Pharmaceutical Society made a formal recommendation to the Privy Council.¹¹⁹⁷ The Pharmaceutical Society, established in 1841, is the professional body representing chemists.¹¹⁹⁸ The society was founded due to concern among chemists and druggists that greater professional exclusivity in the medical profession would damage pharmaceutical incomes.¹¹⁹⁹ They therefore decided to organise to protect themselves against any threats to their livelihoods.¹²⁰⁰ The Society succeeded in limiting the boundaries of the profession and cementing its own authority with a series of Pharmacy Acts from 1852 onwards.¹²⁰¹ They were also responsible, under the 1868 Pharmacy and Poisons Act, for making recommendations on which substances should be covered by poisons legislation.¹²⁰² The Pharmaceutical Society had a defined and respected role.

Some commentators writing in the 1870s suggested that legislation was the best way to systematize the practical recommendations listed above.¹²⁰³ This suggestion was uncommon until the 1880s, with comment focussing on methods that could be implemented immediately and without much effort.¹²⁰⁴ When these failed to reduce mortality, legislation became more important. The first official recommendation from the Pharmaceutical Society was made in 1882, in the wake of a failed attempt at a new bill for poison control which would have included carbolic.¹²⁰⁵ Rather than accepting the idea, however, the Privy Council rejected it out of hand and resolved to proceed alone.¹²⁰⁶ Its version would have imposed control over carbolic acid amongst other minor

poisons, and was reasonably well received by those calling for regulation.¹²⁰⁷ The bill, however, petered out after the 1886 election.¹²⁰⁸ The Privy Council appeared to have reneged on its commitment to regulation, disappointing the Pharmaceutical Society and its allies.

This disappointment, coupled with the ongoing toll of accidental deaths, meant that it was not long before further calls were made for regulation. Medical journals were instrumental in the campaign. *The Lancet* made repeated and increasingly strident calls for carbolic to be included within the Poisons Act in order to reduce the number of deaths it caused.¹²⁰⁹ *The British Medical Journal* also wanted carbolic to be included within a new Poisons Bill and mentioned it several times over the years.¹²¹⁰ The Parliamentary Bills Committee of the BMA made direct calls to the Privy Council and the Pharmaceutical Society for carbolic to be added to the poisons schedule.¹²¹¹ This accorded well with Bartrip's illustration of the other campaigning activities of the BMA and the British Medical Journal over the latter half of the century.¹²¹² The weight of medical opinion was clearly in favour of extending regulation and restricting access to carbolic. This continued pressure was matched by the Pharmaceutical Society, which continued to make formal requests for carbolic to be added to the poisons schedule.¹²¹³ These were rejected by the Privy Council, who claimed that regulation would inhibit carbolic's disinfecting uses, threatening public health.¹²¹⁴ The need for widespread access to disinfectants therefore, for the Privy Council at least, was a compelling reason to reject tighter control, and it cited this as the reason for refusing to acquiesce to further recommendations in 1888.¹²¹⁵

This argument, which was to become the pivotal concern hindering regulation, was disputed by those seeking regulation. Both the Pharmaceutical Society and the *British Medical Journal* felt that the provision for wholesale dealers to sell scheduled poisons if properly labelled would prevent any real limitation of the substance for public health purposes, implying that they referred to mass sales to local authorities and

charities.¹²¹⁶ Regulation was therefore aimed at halting sale through “dubious” retail outlets to the public in general. *The Chemist and Druggist* was also unconvinced of the worth of carbolic as a disinfectant. They highlighted that although it was in widespread use, and the Privy Council claimed it was a good disinfectant, the LGB had made no definite pronouncement on its effectiveness or recommended it. As the LGB did not consider it worthwhile and it caused many deaths there was no reason to allow unrestricted sales to continue.¹²¹⁷ By 1890, therefore, attempts to get carbolic included with the Poisons Act schedules had become the main way of trying to reduce the death toll.

This campaign intensified significantly in the 1890s, fuelled by the huge increase in the number of fatalities attributed to carbolic. Whilst attention had been called to the issue as early as the 1870s, detailed examination of the mortality figures was only undertaken from 1890. Concerns emerged from 1889, and were raised in a number of medical journals and texts.¹²¹⁸ For instance, J. Brendon Curwengen claimed that the Registrar General’s reports showed that carbolic was “a highly dangerous poison in the hands of the public”.¹²¹⁹ The issue, however, really came to the fore in 1893 when Mr. Macdona, an MP, compiled mortality figures using the Registrar General’s statistics, revealing a shockingly rapid increase in the number of deaths.¹²²⁰ He submitted these to Parliament for discussion and attempted to get the figures publicised by the Home Office.¹²²¹ The “scandal” of carbolic deaths was brought to widespread medical attention.¹²²² Both *The Lancet* and *The British Medical Journal* supported Mr. Macdona’s campaign and called for regulation in order to reduce deaths.¹²²³ For the medical profession, therefore, it seemed obvious that the suicide death toll from carbolic poisoning was rising rapidly, and required action. The wider timing of this concern about carbolic is interesting. Safety more generally was a focus of attention in the 1890s, with the government passing legislation on dangerous trades in 1891 and 1895.¹²²⁴ There was a particular debate about women’s safety in the workplace in the 1890s, and the possible links between work conditions, high infant mortality and “the degeneration of the race“.

¹²²⁵ There were also ongoing concerns about patent medicines and other preparations sold to the public.¹²²⁶ The backdrop suggests an increasing role for considerations of safety more generally, albeit one which was refracted through the particular considerations and power relations of disinfection.

Other groups disagreed that there was a problem. The carbolic industry denied that their products were causing higher deaths tolls. Mr. Calvert, a carbolic manufacturer, claimed that the increase in deaths was much smaller than increases in poisoning due to other scheduled substances.¹²²⁷ He also rejected the idea that suicides should be taken into account, as in his opinion they could not be prevented by regulation.¹²²⁸ Manufacturers, being keen to promote their own products, were very much unconvinced of the significance of the high deaths tolls and disputed the relevance of regulation to the problem of suicide.

It is instructive to consider the trends in carbolic deaths in order to see on what exactly this righteous concern and definite rejection was based. Bartrip has illustrated the way in which the arsenic panic of the 1840s was whipped up by the media, and used to advantage by the medical profession.¹²²⁹ Indeed, safety reforms owed much to the emerging ambitions of the Provincial Medical and Surgical Association, the forerunner of the British Medical Association, who wanted to establish their social responsibility and political credibility.¹²³⁰ Their success helped to reposition the Association as a major British institution by the end of the century.¹²³¹ Was the carbolic panic of the 1890s also more to do with media attention than deaths? Figure 6.1 shows the total number of accidental deaths and suicides between 1863 and 1914.¹²³²

Figure 6.1

1233

Deaths increased moderately throughout the 1870s and 1880s but leapt in the 1890s. There was then a decline towards the end of the period. Carbolic was “the most prolific poison” of the 1890s.¹²³⁴

These statistics can be broken down into accidents and suicides. Some suicides were probably returned as accidents, so the two categories were not completely separate. They do, however, show differing trends, as shown in Figures 6.2.

Figure 6.2

1235

This illustrates several interesting points. The greatest proportion and number of carbolic deaths throughout the period was due to suicides. Carbolic rapidly became a cause of accidental death in the late 1860s, peaking in 1878. This could be a result of its initial adoption as a popular disinfectant. Judging from reports, carbolic was initially not widely known to be dangerous, and the bottles lacked warnings. There was a second peak in the mid-1890s. This could be due to continuing unfamiliarity with the chemical's properties, or misunderstandings about how its uses.¹²³⁶ Other explanations are, however, more compelling. This second peak in accidental cases broadly corresponds with the peak in suicides. As Anderson has pointed out, there were variations in whether deaths were recorded as suicides, although there was no systematic change in 1891.¹²³⁷ Taking account of the stigma of suicide is possible that some accidental deaths were actually suicides. We must therefore turn to look at suicides for a better explanation of the 1890s peak.

Explaining the trend over time is difficult. According to Anderson, carbolic was becoming more popular from the 1870s as it was promoted by public health authorities, making it increasingly accessible to those wishing to harm themselves.¹²³⁸ The easy availability of a method was a key determinant of its use; where the immediate availability of methods shifted, so did the number of deaths they caused. It is certainly plausible this was of influence. Many reports attributed some cases to the availability of carbolic in the home or from local retailers.¹²³⁹ It is difficult, however, to get independent information on useage as archives have not survived for any of the major carbolic companies. The carbolic market was so fragmented that it would be impossible to judge its overall size from the sales figures of a few companies. Other sources give an impressionistic overview of changes in sales. Recommendations in household texts seem

to locate the time at which carbolic became widespread in the 1880s.¹²⁴⁰ Complaints about the availability of carbolic had been made for several decades before the 1890s, and although they intensified in the 1890s, this does not necessarily indicate that the substance was any more widely available. Wynter Blyth claimed that carbolic had become “vulgarised” by the 1890s, but that this increase had come “much later” than Lister’s adoption of the chemical in 1868.¹²⁴¹ Indeed, some argued that its use was falling during the 1890s.¹²⁴² The suicide statistics complicate this idea. Whilst the number of carbolic suicides was similar for both sexes, its proportional importance was different. At its high point, carbolic accounted for 15% of all female suicides, but 47% of female suicides by poison. As this trend had been developing since the 1880s, it does seem that wider availability promoted the method. This does not, however, explain the large increase in numbers of deaths, and the percentage contribution of carbolic, in the 1890s. It seems unlikely that the general availability of the chemical could change so rapidly. The overall increase could be due to greater availability, but the 1890s carbolic panic remains difficult to explain.

Whilst the causality remains unclear, the results were obvious. After 1890s the campaign for the regulation of carbolic intensified. The carbolic death toll continued to rise, and it was clear that not all retailers were voluntarily following safe practices. For this reason there was greater emphasis on compelling better practice, the obvious means being regulation.¹²⁴³ Inclusion within the Poisons Act would limit who could sell carbolic, and how they could do it. Registered chemists were thought to be safer as they already followed the proposed precautions in terms of labelling, bottles and other factors.¹²⁴⁴ Even they were not obliged to take the name of the purchaser, or to ask for what purpose it was wanted, meaning that greater regulation could still improve practice.¹²⁴⁵ Conversely, unregistered oilshops and grocers came under fire for selling carbolic in unlabelled teacups, bottles and jars, ignoring even the most basic safety precautions.¹²⁴⁶ Some commentators thought that even having carbolic in a grocers shop alongside household products made it seem safe, and encouraged complacency.¹²⁴⁷ The “unsafe”

availability of carbolic from such outlets meant that even when other retailers refused to sell carbolic, customers could simply go elsewhere, undermining any concept of responsible retail.¹²⁴⁸ Regulation was needed to control the behaviour of these people or exclude them from selling entirely.¹²⁴⁹

There were also wider calls for regulation. Coroners and inquest juries repeatedly recommended that carbolic be added to the poisons schedule to help prevent accidents and suicides.¹²⁵⁰ Mr. A. Braxton Hicks, a coroner in London, personally forwarded a recommendation for regulation to the Privy Council.¹²⁵¹ The medical journals were very active in promoting this idea throughout the decade, and frequently encouraged the Pharmaceutical Society to take action.¹²⁵² The BMA and their Parliamentary Bills committee were also interested in applying control to carbolic, sending recommendations to both the Pharmaceutical Society and Privy Council to take action.¹²⁵³ All of these were discussed in detail in the *British Medical Journal* alongside the journal's own calls for regulation.¹²⁵⁴ This shows the increasing confidence of the medical profession in asserting their authority to advise on any matter related to health, and their enhanced status. Public health bodies and journals, on the other hand, made few statements about the matter, although their support for extending regulation was mentioned in several publications.¹²⁵⁵ It seems they were more concerned with other matters. The *Chemist and Druggist*, a journal representing professional chemists, supported the campaign and recommended that the Pharmaceutical Society take action to stem the "rampant" tide of carbolic poisonings.¹²⁵⁶ The alliance between medical professionals and chemists was relatively unusual, as the two professions were more prone to squabbling over the limits of their jurisdictions in prescribing, retailing and profiting from drugs.¹²⁵⁷ Disinfection shows the ways in which long standing professional rivalries could be put aside, and that in some situations the two professions could agree on their respective roles. Perhaps the most telling request came from the LGB itself. In 1893 they responded to campaigning M.P. Mr. Macdona's efforts by writing to the Pharmaceutical Society to recommend that

they start the process of adding carbolic to the poisons schedule.¹²⁵⁸ With this effort ultimately ending in failure, it made a “strong representation” to the Privy Council itself.

¹²⁵⁹ This level of disagreement shows the fragmentation of responsibility and opinion within central government. Whether resulting from genuine concern or professional sensibilities, the pressure was mounting.

This campaign produced results. In 1892, the Pharmaceutical Society responded to the clamour and, based on the high death tolls, decided once more to recommend inclusion within the Poisons Act.¹²⁶⁰ The society felt that misuse would thus be curbed without affecting public health. After this request was rebuffed, they made two more in

1894 and 1895.¹²⁶¹ The Privy Council acknowledged the calls for regulation but refused to heed them. They thought that the matter was difficult and delicate, and there were practical problems associated with setting carbolic within the existing poisons

framework.¹²⁶² They doubted whether regulation would decrease the number of accidental deaths, as such fatalities from poisons already included in the act were numerous, and most carbolic deaths were suicides which would have occurred anyway.

¹²⁶³ More importantly carbolic was felt to be too valuable to allow any restriction.¹²⁶⁴ Regulation would limit the public’s ability to get hold of a necessary chemical, and would have a negative impact on trade, threatening public health and general economic wellbeing.¹²⁶⁵ All in all, regulation would cause myriad problems and provide few benefits.

These counter-arguments were rigorously denied by those supporting regulation. *The British Medical Journal*, writing in 1894, thought that the existing legislation was perfectly suitable and the only obstacle that remained was the agreement of the Privy

Council.¹²⁶⁶ They also denied that new legislation would improve the situation given the disagreement between the Privy Council and almost all other parties involved in the

debate.¹²⁶⁷ Some rejected the idea that carbolic’s use as a disinfectant meant that it could be allowed to continue being sold over the counter.¹²⁶⁸ The *British Medical*

Journal showed that they supported carbolic being rigorously regulated, even if it meant access to it was curtailed.¹²⁶⁹ Even if carbolic were the only disinfectant available the “constant tribute of human life through accident and suicide” would have been unacceptable.¹²⁷⁰ Another statement in 1896 stated that the high number of deaths meant that regulation, rather than concerns about disinfection, should be the key factor in decision making.¹²⁷¹ They reiterated the statement later in the year, and claimed that carbolic was, on account of the number of deaths caused, “practically the most dangerous poison known”.¹²⁷² Regulation was thus a matter of urgency.¹²⁷³ Similar comments appeared in the popular press. *The Truth*, quoted in the *Chemist and Druggist*, claimed that whatever carbolic’s use in defending the health of the community, the high death toll from suicides meant that control had to be placed on it.¹²⁷⁴ Papers such as *The Times* also expressed shock at the easy facility offered to people to commit suicide.¹²⁷⁵ There was some limited opposition to the calls for legislation, based on promoting accessibility to carbolic as a disinfectant, but the general mood was in favour of regulation.¹²⁷⁶ It is unclear whether the public supported regulation. The *Chemist and Druggist* thought that they would support the campaign and help put pressure on the government.¹²⁷⁷ The issue was, however, much more commonly debated in the professional than the popular press. The sensitive issue of suicide lacked the urgency of other poisoning scandals; the middle class public might have feared arsenic hidden in sweets, but could be confident that they were not at risk of committing suicide. The public were the subject of debate rather than participants. This was a common feature of disinfection debates, demonstrating the extent to which these conversations relied on specialist knowledge and excluded lay-people. There was, nevertheless, agreement on what action needed to be taken. For some the need for regulation outweighed the need for carbolic to continue on sale in the same way as it was currently.

The notion that carbolic’s use would be curtailed by regulation was also, ironically, disputed. Some authors thought that legal measures would reduce its misuse by vetting those who got access to the chemical, whilst allowing legitimate use to

continue.¹²⁷⁸ This argument could be re-interpreted along class lines. An article in 1897 stated that accidents were most commonly caused by crude carbolic, as used by the poor.¹²⁷⁹ This focus on poison as a problem specific to gender and class was not new.¹²⁸⁰ Whilst some of the class differences could be attributed to the “self selecting” nature of pure carbolic sales, it could also be attributed to differences in the way the products were sold. Pure carbolic was sold responsibly, crude carbolic was not. This supported the idea that regulation would make preparations more carefully dealt with.¹²⁸¹ Others argued that the use of substances already included within the Act, such as mercury chloride, had not been curtailed, and there was no reason to suppose that carbolic would be different.¹²⁸² This was a rather troubling given the number of deaths caused by scheduled poisons. There was, however, concern from some areas that carbolic was irreplaceable as a disinfectant, and so regulation should not cut off the supply.¹²⁸³ Scheduled poisons would still be available to the public for purchase and, although prices might be higher, they would not be beyond the reach of consumers.

On the other hand, some commentators thought that regulation would simply redirect the type of carbolic sold, replacing carbolic solutions with powders.¹²⁸⁴ For these reasons, control of some forms of carbolic would not limit the use of other, equally useful preparations.¹²⁸⁵ Others argued that it was unlikely that restrictions would lead to a decline in disinfecting as there were plenty of non-poisonous disinfectants available.¹²⁸⁶ These comments were out of step with ideas about the effectiveness of carbolic powders and commercial preparations, demonstrating the complexity of the issues and the confusion among those writing about them. The suggestion that carbolic was a necessary part of protecting public health was opposed on a number of conflicting fronts and there was no clear vision of how regulation would affect the supply. Carbolic had been rejected as a germicide before the 1890s, but only became a pressing concern when it became a public safety problem. If it was safe and ineffective, then continued use was a matter for education on better disinfection methods. When it became unsafe, however, its sale could not be tolerated any longer.

By 1896 it was obvious that the existing poisons framework was not functioning properly. Despite the Privy Council's misgivings, the rising pressure it was under due to deaths, the press and the professions caused them to consider a general revision of the Poisons Act.¹²⁸⁷ Concerns continued to be raised.¹²⁸⁸ The Privy Council rebuffed these additional demands, stating that the matter was under consideration and they would reply in due course.¹²⁸⁹ It seems that the Council was indeed considering the issue, albeit slowly, and hoped that this new approach would break the deadlock. The response to the delay from the journals was scathing. *The Chemist and Druggist* stated that the Council should be "ashamed" of such a lukewarm response, especially given that twenty years had passed with no progress.¹²⁹⁰ *The British Medical Journal* accused the Council of neglect and of having no adequate reasons to delay.¹²⁹¹ By 1899 it was even more irate, pointing out that it had been over two years since the matter had come under consideration, and no bill had appeared.¹²⁹² The slow progress of the campaign demonstrates the relative weakness of new professional bodies in the face of Government inertia. Whilst respect for expert opinion had grown in the latter half of the century this did not give the professions control over policy.

The Privy Council eventually reported back with a new bill in 1899, some three years after initially suggesting it.¹²⁹³ The bill aimed to overhaul the schedule of poisons and bring in an intermediate level of control. This would allow a compromise which would tighten the conditions of sale for poisons such as carbolic, whilst maintaining widespread availability. The bill was, perhaps unsurprisingly, unpopular with those seeking regulation. By putting no limits on where carbolic could be sold, normal retail outlets would continue their trade, leaving the primary location of unsafe sale untouched.¹²⁹⁴ Both *The Chemist and Druggist* and *The Lancet* claimed the bill was a retrograde action which barely restricted the sale of carbolic and was hardly worthwhile.¹²⁹⁵ The Pharmaceutical Society was also incensed by the removal of control to the Privy Council and the exception in the bill that would allow unlicensed persons permission to sell some

scheduled poisons.¹²⁹⁶ Pharmacists had worked hard to protect their profession from encroachments, and the proposed bill was seen as a slur on this status.¹²⁹⁷ This concern was also about safety; for the Society, the formal ritual of sale in a registered chemist's shop added an additional level of caution that could not be gained any other way.¹²⁹⁸ The measures proposed in the bill were sufficiently flawed that it was suggested it would be opposed actively by those who had initially called for regulation.¹²⁹⁹ Whether this opposition would actually have occurred is unclear as reactions to the proposed bill were not wholly unfavourable.¹³⁰⁰ As it turned out, however, this was not necessary as the widespread criticism meant that the bill was dropped.

Instead, the Privy Council agreed on a new bill which mandated that preparations containing over 3% of carbolic acid or its homologues were to be sold only by approved retailers.¹³⁰¹ This upheld the role of chemists in poison retail and supported their professional status. Carbolic had to be supplied in bottles distinguishable to the touch and clearly labelled as poison.¹³⁰² These recommendations built in many of the measures that had been advocated for decades and satisfied most of the demands of those calling for regulation. There was finally a measure of support for the Privy Council from the journals, the medical profession and chemists, who praised the bill.¹³⁰³ The length of time, nearly ten years, taken to achieve any progress was not necessarily unusual; Wohl has pointed out that government was often slow to impose outright bans in relation to dangerous trades, but instead put their faith in sanitary improvements and factory regulation.¹³⁰⁴ There are clear parallels with carbolic regulation, although the presence of an existing structure for new poisons caused many groups to expect more rapid action. Whilst the bill had been slow to appear, *The British Medical Journal* thought that it at least made some headway.¹³⁰⁵ It exhorted the Privy Council to press on and make sure that the measure was enforced effectively.¹³⁰⁶ *The Lancet* was less favourably impressed with the terms of the bill, but was pleased that action had at last been taken.¹³⁰⁷ It

seemed, therefore, that safety had won out above guaranteeing the availability of carbolic in the concentrations at which experts thought it to be effective as a disinfectant.

The medical and public health community, as well as registered chemists, had followed the campaign closely and were well aware of the passage of the regulation. The Privy Council also took steps to ensure that public health authorities knew their responsibilities under the legislation, and sent a circular to all sanitary authorities setting out the terms of the legislation.¹³⁰⁸ Nevertheless, publicising the new regulation was troublesome and the Privy Council was accused of not taking adequate steps to ensure that common retailers knew about the order.¹³⁰⁹ They had publicised the Order in the *London Gazette*, but this was not the type of paper which oil dealers or their customers usually read. The journals therefore recommended that the Council should publish the recommendations in the daily papers, which their intended audience would be more likely to read and take notice of. As well as ignorance, instances of disobedience are also evident in various sources.¹³¹⁰ These were difficult to detect and deal with as the Pharmaceutical Society had no way to identify or punish offenders.¹³¹¹ There were therefore calls for the Privy Council to implement the measures more strictly and consistently so as to reduce the death toll further.¹³¹² Nevertheless, they made relatively little effort to do so, leaving a loophole whereby the law could be rendered ineffective.¹³¹³ The Privy Council had passed the measure but seemed to be in no great hurry to make everyone aware of it.

The regulation also attracted direct criticism from several angles. It understandably faced complaints from retailers who would be affected by the new rules.¹³¹⁴ They were opposed to their trade being, as they saw it, unfairly damaged for little public benefit.¹³¹⁵ The medical and chemical journals saw this as irresponsible retailers attempting to defend their unsafe trade and urged the government to ignore them.¹³¹⁶ The medical and chemical journals thus defended their right to decide on safe disinfection. Nevertheless, some professionals continued to maintain that the regulation

would be detrimental to disinfection.¹³¹⁷ In 1902 the *Public Health Engineer* argued that the regulation had limited the sale of carbolic for public health purposes. It disagreed with the notion that the chemical was particularly dangerous, and thought that the actions of “one or two” suicidal maniacs should not have spoilt things for everyone else.¹³¹⁸ This journal therefore contested the idea that carbolic was not an effective disinfectant and thought that public health workers should be the ones to set the parameters of disinfection.

The supporters of regulation were also concerned about potential impact on disinfection effectiveness. The law controlled only those substances containing over 3% carbolic acid. Many medical commentators believed that this would merely encourage manufacturers to downgrade the carbolic content of disinfectant preparations, making them less effective. Regulation had “placed a premium on inefficiency”.¹³¹⁹ This concern was not baseless, and some manufacturers claimed they had done this to avoid their products being restricted.¹³²⁰ The 1909 Milroy lectures, reporting after much of the fuss had died down, claimed that the 1900 Order flooded the market with “less than 3% carbolic” preparations.¹³²¹ It seems that the law did indeed accidentally promote ineffective disinfectants. There were repeated calls from the medical and chemical journals for the LGB to deal with this; as the authority responsible for public health, it was the most appropriate body to appeal to.¹³²² The Board initially promised to investigate, but the response was lukewarm at best.¹³²³ They claimed that they had no authority to fix the standards of disinfectants, and could take no action.¹³²⁴ Instead, they recommended that local MOsH supervised the use of disinfectants to ensure it was effective; they also railed against the use of disinfectants as domestic deodorants, seeing this as an unhelpful misapplication.¹³²⁵ Their statements indicate that they thought that MOsH should make the choices about disinfection and discourage disinfection as undertaken by householders. Their support for regulation relied on putting disinfection in the hands of professionals, not the public, reinforcing the trends seen in Chapter Five.

It seems that regulation had not been able to effect all the changes hoped for. Some were positive about the effects, claiming that the law had moved towards “stamping out” carbolic as a cause of suicide in London, although its effects in other areas were far sketchier.¹³²⁶ By 1902, however, the same journal had changed its mind and stated that despite arguments to the contrary, there had been little immediate curbing of the sale of carbolic, as it was “infinitely more difficult to uproot a tree than a sapling”.¹³²⁷ Chemists and manufacturers denied any reduction in sales.¹³²⁸ This indicates that 1900 was not the discontinuity that many believed. This was good news for those who saw carbolic as essential to public health, but bad news for those who thought that widespread sales were a factor in its misuse. Others nevertheless thought that there had been shift in consumer preferences, pointing to a move of attention towards safer creolin and other weaker coal tar preparations; they were also potentially less effective disinfectants.¹³²⁹ The fears that the public would be pushed into the arms of less effective disinfectants was thus well founded.

What then of death tolls? Some authors argued that regulation had decreased the number of accidental and suicidal deaths due to carbolic.¹³³⁰ Nevertheless, others commented on the lack of impact of the legislation. Some publications continued to make worried statements about the number of deaths caused by carbolic. Haxton Giffen, writing in 1901, stated that carbolic continued to account for large, albeit decreasing, numbers of deaths.¹³³¹ Others commented on the high death toll even up to 1911, when an article stated that deaths and injury from accidental ingestion of carbolic were “not infrequent”.¹³³² These statements can be explored with reference to the Registrar General statistics illustrated in Figure 6.1 and Figure 6.2. A sharp year-on-year decline in deaths can indeed be identified in both 1900 and 1908, when regulation was respectively introduced and extended. Nevertheless, these breaks were part of an underlying decline from the mid-1890s onwards. This would seem to indicate that regulation was not the only influence at play.¹³³³ It is clear that regulation cannot fully explain the trend, meaning that it was not as successful as some people thought.

As well as adjusting the regulations concerning carbolic, Parliament also appointed a committee in 1901 to consider a more general revision of the Poisons Act.¹³³⁴ Its membership included several chemists and scientists but no medical or public health professionals; whilst the primary focus of the investigation was carbolic's use in agriculture, the omission of medical professionals was perhaps an indication of how their concerns were going to be treated.¹³³⁵ The committee took evidence from a range of interested parties including chemists, manufacturers, coroners, doctors, and representatives of agriculture and horticulture, and reported back in 1903.¹³³⁶ They initially recommended that carbolic preparations required for agriculture, horticulture and sanitation needed to be excluded from control.¹³³⁷ Clearly, the evidence that was presented to them was convincing enough to indicate that these needs were pressing, and ill served by existing regulation. The recommendation for exceptions on grounds of sanitation is very interesting in view of fears about the damage to public health engendered by controlling carbolic. Nevertheless, this exception was dropped before the recommendations were formulated into law in 1908.¹³³⁸ The power of agricultural interests was greater than any sanitary influence.

Another change came in 1913, when, in response to the ongoing concern about preparations below 3%, regulation was extended to all carbolic preparations.¹³³⁹ As a compromise to ensure easily availability to the public, however, there was no limitation on where they could be sold so long as they were properly labelled.¹³⁴⁰ The Privy Council intended this regulation to settle the problems that had appeared after the 1901 regulation, and to sidestep the calls for regulation of the strength of disinfectants. On the face of it this new measure placated the public health interest. Nevertheless, the continued differential in retail location between weak and strong carbolic preparations meant that it was still much easier to acquire ineffective, rather than effective, disinfectants. By 1914, therefore, calls for the regulation had been firmly met, and all types of carbolic and its homologues were within the remit of the Pharmacy Acts. The repeated calls for increased safety in carbolic disinfection had paid off, albeit with

concessions that attempted to placate opposing interests.

The view of the public in these debates is interesting. On the one hand, continuing advice to the public to use toxic disinfectants such as corrosive sublimate and carbolic acid demonstrated that the need for germicidal efficacy in disinfection legitimised the use of dangerous chemicals. Warnings, labelling, and education would make them safe enough to use. In this way, the importance of effective disinfection necessitated public use of dangerous chemicals. On the other hand there was an implication that some sections of the public were not able to cope with the responsibility of handling certain substances, in particular carbolic acid. The intensification of safety advice highlighted that when given injunction to use such chemicals, the public -in particular the working classes -could not be relied upon to use them responsibly, even where extensive information had been provided.¹³⁴¹

For these reasons, legislation was needed to allow professionals, in this case chemists and some medical practitioners, to judge the suitability and intentions of those buying disinfectant substances, and to decide on that basis whether they should be allowed to proceed in their purchase. In this way, although those promoting disinfection wished the public to be active participants in disinfection, the results of this could prove highly problematic and needed to be controlled. Nevertheless, there was an interesting countervailing argument to this. As mentioned earlier, there was significant concern about the use of ineffective disinfectants. Many “safe” disinfectants were also reckoned to be ineffective at killing bacteria, sometimes implicitly based on the very basis that they were “non-toxic”. It was also suggested that the public did not truly understand the importance or aims, of disinfection, and were thus misled by slickly marketed commercial preparations that were ineffective in practice. The debates on safety demonstrate ambivalence to the role the public played in disinfection. Whilst public co-operation was needed, they were often characterised as being likely to poison themselves with effective disinfectants, or lull themselves into a false sense of security with ineffective “safe” preparations. Safety regulation could therefore threaten public health by undermining effective disinfection while strong disinfectant preparations could endanger it by poisoning people.

Conclusion

The varying debates about safety and disinfectants illustrate a number of countervailing and interesting trends. Safety was clearly of concern to some authors and was frequently listed as one of the characteristics a good disinfectant needed. Safety concerns also influenced fumigation practices, as the imperatives of germicidal effectiveness and safety moved in the same direction and reinforced each other. Safety was not, however, a totally limiting factor. Despite these concerns and their impact, professional and popular advice texts continued to recommend toxic preparations for home use, even where their properties were acknowledged. Debates about safety thus did not preclude the recommendation of certain disinfectants where germicidal efficacy or custom made them desirable. These points can be seen even more clearly in the specific discussions of approaches to Burnett's fluid, corrosive sublimate and carbolic acid. Nevertheless, it was only when a widely-used disinfectant was misused as a tool for suicides that attention was really focussed on the problem of disinfectant safety. This attention attempted to balance the needs of disinfection and public health with those of public safety, first by practical measures, and then by legislative effort. The exact boundaries of what regulation should allow were not always clear, and establishing where the lines should be drawn was contentious. The debates also show the power relationships between the various groups involved. The medical and chemical professions expected to be able to advise policy, and were eventually successful, but this was not straightforward; even where one government department agreed with a policy change others could disagree and progress could be incredibly slow. Whilst the professions were increasingly confident their ability to shape change was limited. The relative lack of interest from the public and local government is also clear and these debates were confined to limited professional circles. The public did not concern itself with a scare that centred on illegal behaviour, namely suicide.

These safety debates also show how certain views of the public differed from those of some members of the medical profession. The public's involvement in disinfection was increasingly necessary, but this involvement produced actual and imagined problems both in relation to safety and germicidal efficacy. The public was prone to misuse poisonous disinfectants and thus kill themselves, or to be taken in by advertising and to sacrifice germicidal efficacy for safety. The professions thus wished the

public to walk a very fine line between safety and efficacy, and one which the professions seemed to believe was rarely met, and that they themselves failed to agree on. Debates on safety were thus riven with tensions regarding the role of the public, especially the working class, in disinfection, and demonstrated the extent to which their participation, whilst necessary, produced new problems.

Chapter Seven: Standardising and Testing Disinfectants

As discussed in Chapter Two, the definition of disinfection changed after the advent of germ theory. Older methods of disinfection were discredited, whilst newer methods, such as formalin, underwent a rigorous testing process.¹³⁴² Germ theory seems, therefore, to have provided certainty; as Samuel Rideal and James Ainslie Walker confidently claimed in 1906, bacteriology had replaced earlier “rudimentary” methods which, even as late as 1890, had been unable to distinguish between effective and ineffective disinfectants.¹³⁴³ Nevertheless, although germ theory did provide a new framework for understanding the action of disinfectants there were complexities and problems, especially in relation to practical disinfection. This chapter examines this increasing gulf between theory and practice through the prism of the standardisation of methods of testing disinfectants’ efficacy. The increasingly specific, complicated and rarefied nature of testing methods led to conflict between experts about which to use. Their debates acknowledged the real-life uses of disinfection, and that their methods needed to provide results which were applicable in practice. Nevertheless, popular laboratory methods often circumvented these issues in their search for comparability and scientific standards. In this way, bacteriological testing provided a dizzying range of information whilst increasingly operating on a level incompatible with that used by most disinfection practitioners. This can be illustrated in the debates concerning standardisation of disinfectants, a controversy that spoke more of the needs of researchers and manufacturers than of users. Standardised methods showed how disinfectants performed in a laboratory, under controlled conditions and unaffected by the obstacles encountered in practice; the results could therefore be irrelevant or misleading for those undertaking disinfection. This chapter identifies and investigates this divergence between

laboratory and practical methods throughout the century, highlighting the essential problem that as the possibility of more certain knowledge grew, testing diverged from the needs of practice.

Testing disinfectants in the pre-germ era

The first section of this chapter investigates whether, and how, the value of disinfectants was assessed in the first half of the century. As we have seen, later authors have assumed that disinfectant testing was a result of germ theory. The evidence presented here highlights that a more systematic approach to testing disinfectants was not newly developed in the age of germ theory; testing effectiveness was a theme throughout the century, utilising a range of methods.

There is clear evidence from the first half of the century of awareness of the need to provide evidence of the effectiveness of disinfectants. Some commentators before 1860 called for both “scientific research” on disinfection, and proof of effectiveness.¹³⁴⁴ Such clear statements were, however, uncommon, and the perceived importance of testing disinfectants increased in the mid-1860s.¹³⁴⁵ 1866 has been identified as a key turning point in disease-prevention policy. The cattle plague led to the development of a system of stamping out which included disinfection.¹³⁴⁶ The increasing focus on what exactly was needed to prevent disease led to the first lengthy texts on disinfection and a greater focus on its role.¹³⁴⁷ Explicitly assessing the effectiveness of methods of disinfection was an essential part of convincing medical practitioners, government and the public that this was a necessary policy, and prompted a wider interest in disinfection effectiveness. This continued into the 1870s and 1880s, with authors calling for “scientific” methods to be applied to testing in order to give the medical profession and public better understanding of which disinfection methods were effective.¹³⁴⁸ The increased importance of testing linked into the widening range of disinfection as a public health intervention.

By what methods was disinfection evaluated? Experimental practice in the first half of the century focussed on practical approaches, such as observing cases of disease, or on examining the effects of substances on decomposing objects.¹³⁴⁹ Case tracing was

a popular approach with a long history. An early use of the method was the observations on the effectiveness of nitric acid made by Dr. Smyth in 1796 and 1802.¹³⁵⁰ He judged its effectiveness by observing the number of repeat cases and deaths, and found that it significantly reduced both.¹³⁵¹ The method developed over the following decades. The lack of reappearances of epidemics was often seen as proof of the effectiveness of disinfection.¹³⁵² However, a smaller death toll when disinfectants were used as opposed to when they were not was also seen as proof of beneficial effects of disinfection.¹³⁵³ The use of intermediate objects as a test of disinfection was also raised. A key example is the famous experiments on heat disinfection undertaken by Dr. Henry in the 1840s. His method entailed heat treating clothing from scarlet fever and smallpox patients, giving the clothing to susceptible persons, and then observing whether they contracted diseases.¹³⁵⁴ His experiments, although later regarded as an incomplete scientific demonstration of heat's effectiveness, were nevertheless "strong presumptive evidence".¹³⁵⁵ A lack of illness had many qualities which made it an attractive source of evidence on disinfection.

Case tracing remained important after 1866. It was used in official reports on the cattle plague.¹³⁵⁶ It was also championed into the 1870s and beyond by popular authors including E. Parkes, in particular for assessing, and indeed undermining, methods such as fumigation.¹³⁵⁷ It was also the most suitable method to assess the disinfection of diseases without an identified causal agent, due at least in part to the lack of alternatives.¹³⁵⁸ For these reasons some commentators thought that experience was a better guide to what actually works than laboratory experiments.¹³⁵⁹ Case tracing was also the favourite approach of local MOsH from the 1870s onwards. It was used to assess policies combating smallpox in Bolton up to 1903, and formed the backbone of the St. Helens MOH's arguments that disinfection combated scarlet fever.¹³⁶⁰ In this way, the repeat cases method remained a crucial tool for those who worked on practical disinfection. The simple, apparently obvious and "common sense" nature of the method gave it continued

practical applicability throughout the century.

There was, however, increasing criticism of these ideas. The intellectual underpinnings of the method were unconvincing for many. H. Kenwood, writing in 1908, claimed that the non-recurrence of disease was not proof that disinfection was effective, and that researchers and public health workers should think more widely.¹³⁶¹ Articles which used practical evidence as their basis continued to appear but were criticised.¹³⁶² One author claimed that “assuming that assured disinfection is to be had by processes that do not even work in the lab is to adopt the course of the ostrich, except that the bird is more certainly enlightened by the course of events”.¹³⁶³ Case tracing was also not mentioned as a legitimate method in any specialist manual of disinfection.¹³⁶⁴ Indeed, determining secondary cases of illness due to imperfect disinfection was seen as difficult.¹³⁶⁵ The difference between methods used in local investigations and scholarly research is clear. Whilst case tracing was an important, durable and pervasive means by which disinfectants were judged, and was the leading method before 1860, it was increasingly criticised as more direct approaches became available.

Other proxy methods of testing continued to be positively regarded throughout the century. Animal testing built on the case tracing method and adapted it to laboratory methods. This usually took the form of disinfecting a substance and then injecting the disinfected material into an animal to see if the disease was produced. Inoculation methods had been used by a number of researchers in the first half of the century, including Dr. Henry and Dr. Baxter, and continued to be used alongside bacteriological methods throughout the 1880s.¹³⁶⁶ Bacteriology increased the substances that could be used for animal testing as pure cultures, such as anthrax, were now available.¹³⁶⁷ Animal testing was often incorporated into bacteriological research.¹³⁶⁸ One example of this was S. Delepine and A. Ransome’s work on tuberculosis, which used guinea pigs alongside detailed laboratory tests.¹³⁶⁹ By 1890, Wynter Blyth identified two main ways of testing disinfectants: by animal experiment, and by testing cultures.¹³⁷⁰ He regarded

both methods as useful and reliable.¹³⁷¹ The importance of animal research is clear. These methods, however, came second to testing the direct effect of disinfectants in killing bacteria. Whilst animal testing could take a similar amount of time, animals were more costly and troublesome than bacteria to buy and handle. The Cruelty to Animals Act, 1876, added a series of conditions to experiments using animals; researchers had to apply for licences before they were allowed to undertake animal experiments.¹³⁷² Inoculation experiments did not require the more complicated permissions prescribed by the Act but still required basic clearance. This meant seeking a licence, supported by a leading medical or scientific body, which was reviewed on an annual basis and had to be used for a specified number of experiments, conducted according to humane conditions in a specified locality.¹³⁷³ This control led to some bizarre studies. In 1884, Hatfield Walker tested disinfectants on vaccinia, which he then used to vaccinate babies, as the law had limited his access to animals.¹³⁷⁴ Animal testing was used in exceptional cases and alongside other methods to establish the reliability of disinfectants, but was not as common as bacteriological methods.

Chemical methods were also used to test disinfectants. These, which concentrated mainly on coal tar derivatives, tested the proportion of the active ingredient present in the sample, indirectly estimating its disinfectant value.¹³⁷⁵ Some supported chemical methods as a viable alternative to bacteriological testing. Chemical methods were used by researchers, in particular chemists, during the 1880s and 1890s as a simple way to estimate disinfectant effectiveness.¹³⁷⁶ For example, in 1890 Wynter Blyth discussed using them to test the purity of carbolic acid.¹³⁷⁷ This meant that solutions could be compared by their chemical purity, rather than by difficult bacteriological tests. The methods continued to be recommended after 1900 as they were seen as useful, accurate and easier than bacteriological approaches.¹³⁷⁸ Some manufacturers were also in favour of chemical methods as these could support their claims about their products.¹³⁷⁹

The validity of chemical methods was, however, increasingly discredited after

1900.¹³⁸⁰ General scepticism gave way to outright criticism of the principles underlying the method.¹³⁸¹ Chemical methods did not take into account that disinfectants were often greatly affected by the physical conditions they faced as well as their chemical composition.¹³⁸² The criticism mounted so that by 1909 *The Lancet's* disinfection committee claimed that such research had been “discredited and ridiculed”, leaving bacteriological testing as the key method.¹³⁸³ The results of the Commission’s research, however, demonstrated close correlation between the predicted disinfectant powers based on chemical experiments, and the actual powers observed in practice.¹³⁸⁴ Chemical testing was therefore advocated as a way to compare disinfectants.¹³⁸⁵ *The Lancet* also predicted that such methods would become more important, especially when combined with information from bacteriological tests.¹³⁸⁶ There is evidence that this occurred. The method of testing coal tar disinfectants attracted attention from readers who wished to replicate it themselves.¹³⁸⁷ Others were also supportive of chemical methods as part of a varied arsenal of tests. Wynter Blyth suggested a combination of methods was best, as did Beveridge and Wanhill.¹³⁸⁸ Despite continuing questions over their usefulness, chemical methods remained in use until the end of the period covered by this thesis. In this way, non-bacteriological methods continued to be used throughout the nineteenth century and beyond, although they did take on a more laboratory-based form.

Evaluative measures based on direct observation of the effects of a disinfectant were also used in the first half of the century. This took a variety of forms. One method, used by several authors, was judging the ability of disinfectants to remove bad smells.¹³⁸⁹ Nevertheless, by 1856 Kostoven doubted that removing smells meant that a disinfectant killed contagia; evidence derived from this method was therefore unreliable.¹³⁹⁰ As the century wore on, removing smells was clearly defined as the property of a deodorant, not a disinfectant, and it disappeared from discussions of effectiveness.¹³⁹¹ The effects of disinfectants on putrefaction was also utilised to test their efficacy, drawing

on the conflation of disinfectant and antiseptic action. These methods were most commonly used in the first half of the century but they persisted later into the century.

¹³⁹² Sporadic references to assessing putrefaction as an easy way to quantify disinfectant action continued into the late 1890s, even after halting putrefaction was not regarded as true disinfection.¹³⁹³ This method also formed the basis for the first quantified approach to testing disinfectants. Robert Angus Smith's crucial 1869 work put forward a systematic version of the putrefaction method.¹³⁹⁴ Smith used samples of specially treated blood to which disinfectants were added; the samples were then allowed to decay and the volume of gas released measured.¹³⁹⁵ It was assumed that decomposition reflected the actions of germs in the substances, and thus halting decomposition showed the action on germs.¹³⁹⁶ Smith's research provided a way that the actions of disinfectants could be compared in a direct, laboratory-based method that identified the action of germs. Smith himself claimed that his method was the first that had been adequate to test disinfectants, and despite the controversy over his conclusions, his approach was generally accepted as reliable.¹³⁹⁷ The beginnings of the impact of germs on the testing of disinfectants can thus be seen in the late 1860s. Whilst testing was still relatively limited, it did put forward coherent information on which disinfection could be based.

Germ theory, bacteria and new methods

The development of research from the 1870s shows the impact of "germ theory" on disinfectant testing. As we have seen, it was starting to influence definitions of disinfection in this period. These developments also led to new types of disinfectant testing. Methods similar to those used by Smith continued into the 1870s, but were increasingly superseded by approaches which studied disease organisms directly.¹³⁹⁸

Initial moves towards bacteriological testing of antiseptics occurred early in the 1870s. In 1871 Dougall tested a range of antiseptic compounds on what he termed "animaculae", judging their effectiveness by the reduction in movement they induced.¹³⁹⁹ This bacteriological testing of antiseptics was soon extended to disinfectants. In 1873, Smith discussed experiments undertaken by Dr. Crace Calvert. Calvert distilled a

mixture of albumen and water so that it was free from any germs, then added disinfectant. The samples were kept at a constant temperature and observed over the next few weeks, and used to determine how many days it took for germs to reappear in each sample.¹⁴⁰⁰ Whilst this was actually measuring the inhibitive action of substances the importance of testing on germs is clear.¹⁴⁰¹ As the decade progressed others adopted germ processes for testing. By 1875 Buchanan and Baxter had tested the antiseptic and disinfectant effects of various substances on impure cultures.¹⁴⁰² Other similar research from a range of authors emerged.¹⁴⁰³ Some used this research to shape their disinfectant advice.¹⁴⁰⁴ These methods were adopted before there was consensus on the relationship between germs and disinfection, demonstrating the plurality of definitions acceptable at the time. This linked to wider developments in the use of laboratory methods. T. Romano has argued that the 1870s saw the triumph of laboratory research over clinical observation in the development of etiological theories.¹⁴⁰⁵ Other methods nevertheless continued to be used: for example, Parkes and De Chaumont argued that the only way to test disinfectant was by direct observation of cases as, in their opinion, germ theory had not been proven.¹⁴⁰⁶ The role of direct experiment as the only true evidence for effective disinfection was supported by other comments throughout the decade.¹⁴⁰⁷ Older methods retained relevance alongside bacteriological testing, and germ theory did not cause a complete re-evaluation of the ways disinfectants were evaluated.

As bacteriology became more developed manuals and handbooks started to emerge from the mid-1880s onwards, giving advice and practical instruction on how to use bacteriological techniques.¹⁴⁰⁸ At the same time, improvements in culture techniques, especially those developed by Koch, meant that by the early 1880s disinfectants could be tested on pure cultures.¹⁴⁰⁹ Koch criticised case tracing, putrefactive methods and animal testing as, respectively, unreliable, incomplete and impractical; their inadequacies, combined with a lack of understanding of the nature of contagia, meant very little had as yet been ascertained about which disinfectants were

useful.¹⁴¹⁰ New methods of testing needed to be developed. Koch was in favour of bacteriological testing but also identified its problems. It could not be assumed that all contagia resembled each other, or indeed that they were microorganisms. Strict accuracy would therefore demand that all disinfectants be tested individually on each agent they were expected to disinfect, a challenging proposal. Despite these drawbacks, bacteriological testing provided the best means of showing the action of disinfectants on infectious materials. Pure cultures of both spore-bearing and non-spore bearing bacteria could be examined in the conditions encountered in practice, and used to determine the exact action of disinfectants.¹⁴¹¹ These experiments should then be repeated to verify the conclusions.¹⁴¹² In this way Koch defined the new era of disinfectant testing: research was to be based on single culture testing, representative of the most difficult bacteria and conditions encountered. Testing on bacteria was, however, only the start of establishing disinfectant effectiveness.

This new bacteriological research was rapidly adopted and many articles and texts from the 1880s utilised these methods.¹⁴¹³ Authors expressed the hope that this new research would “give a precision to the science of preventative medicine ... and deal a blow at the reputation of many a disinfectant sold by cupidity and bought by ignorance”.¹⁴¹⁴ The aim was to unsettle the existing disinfectant hierarchy, with commercial disinfectants a particular target. By 1889 laboratory-based bacteriological testing of disinfectants was a well established means of assessing their value.¹⁴¹⁵ Official research was also undertaken along these new lines. The Report of the Medical Officer of the LGB for 1882-3 contained work by Dr. Buchanan comparing the action of various disinfectants using bacteriological methods.¹⁴¹⁶ This paralleled the increase in importance of laboratories elsewhere in health research. During the 1880s and 1890s new laboratory-based research institutes were set up.¹⁴¹⁷ These institutions were influential in promoting laboratory science and its uses in research, diagnostic and even curative medicine.¹⁴¹⁸ Whilst laboratory methods did not become common in British public

health work until the 1890s it is clear that the growing importance of such methods in research more generally was of wider influence.¹⁴¹⁹

Although bacteriology was most often discussed in relation to chemicals in solution, it was not limited to these disinfectants. The effects of gaseous processes such as fumigation were sometimes examined using bacteria.¹⁴²⁰ Cultures were set up in strategic places around a room, which was then fumigated and the organisms re-cultured to see whether they had been killed.¹⁴²¹ This blended bacteriology with the practical methods discussed above. The link between testing and practical conditions, however, weakened as time went on, although some examples of such testing can be found after 1900.¹⁴²² Bacteriological testing was also utilised in assessing heat disinfection.¹⁴²³ The experiments used microbes which were put in heat chambers and disinfected, and then transferred to new culture media to see how they grew.¹⁴²⁴ Indeed, bacteriology was a key source of evidence in the debates concerning the effectiveness of steam disinfection.¹⁴²⁵ Laboratory experiments, albeit ones which recognised the needs of practical disinfection, had therefore become the gold standard of testing for a wide range of agents. Nevertheless, in the majority of cases the effectiveness of such methods was worked out in the laboratory and then applied to practical situations by analogy. As the temperature needed to kill bacteria became clearly defined, direct experimentation on bacteria receded in importance.¹⁴²⁶ Physical tests, such as thermometers and pressure gauges could be used to see if the conditions in disinfection chambers matched the laboratory average.¹⁴²⁷ This was allegedly more reliable than testing individual cultures and became the most common way to approach the problem.¹⁴²⁸ Where the conditions needed were agreed on non-laboratory methods could be used to ensure that they were met.

By the 1880s, therefore, bacteriological methods had been applied to a range of disinfectants. There was, however, concern that research had not progressed far enough. The range of contagia which could be experimented on was limited and often ignored

spore-bearing bacteria.¹⁴²⁹ The effects of disinfectants on viral diseases could not be studied because viruses had not yet been identified, although vaccine lymph could be an adequate stand-in for smallpox.¹⁴³⁰ Various methods of testing were also used, reducing the comparability of results. Koch used thread-based methods, Fisher and Proskauer used solid agar cultures, and other researchers used broth cultures.¹⁴³¹ There was, however, comparatively little discussion of which method was best. Whilst there were clearly concerns that methods should be reliable and defensible, the debates did not prioritise the need for a standard approach.

The drawbacks of laboratory testing were highlighted throughout the whole period. Some authors felt that it was impossible to be dogmatic that germs caused disease, meaning that bacteriological testing provided incomplete evidence.¹⁴³² Concerns that the products of bacteria also needed to be combated led commentators to call for this to be included in testing.¹⁴³³ This view was repeated by germicide dissenters including Mr. Kingzett, of the Sanitas Company.¹⁴³⁴ Ongoing concern about definitions of disinfection thus led to opposition to bacteriological testing. The relationship between old and new evidence could also be troubling. An article in 1882 analysed the action of disinfectants on putrefying matter and on germs, concluding that the two bore little resemblance.¹⁴³⁵ This incompatibility shaded into concerns about the usefulness of methods. The applicability of disinfectant testing to practical situations was also a matter of serious concern for many authors. Crookshank claimed that careless testing led to misleading or mistaken information which was not applicable to practice.¹⁴³⁶ *The Lancet* agreed, and claimed that there was a huge difference between theorising about disinfectants and testing their application thoroughly and practically.¹⁴³⁷ Ransome also claimed that the ultimate test of disinfection was actual practice, and advocated that this evidence should come from the work of local authorities.¹⁴³⁸ Wynter Blyth also continued to use older methods alongside newer bacteriological testing: he undertook experiments on the anthrax bacillus but also carried out deodorising experiments on

sewage.¹⁴³⁹ In this way, some commentators appealed back to older ideas as a way to confirm the conclusions drawn by “science”, and there was awareness that laboratory testing needed to be carefully controlled in order to continue to be useful.

This confidence in bacteriological testing continued into the 1890s.¹⁴⁴⁰ At the start of the decade Koch claimed that the new methods gave certain knowledge of the effectiveness of disinfectants, a significant improvement on the previous situation where people had been “working in the dark”.¹⁴⁴¹ This optimism was evident in a number of other publications which claimed the new testing was “scientific”, “effective”, “precise” and “reliable”, as well as “the only defensible way to test disinfectants”.¹⁴⁴² New research was thought to have changed the substances that were regarded as disinfectants, and would help improve disease prevention.¹⁴⁴³ The advice given in texts and handbooks drew on this new bacteriological research, deploying evidence to back up recommendations of which disinfectants should be used.¹⁴⁴⁴ This progress, however, seemed less impressive with hindsight. Rideal and Walker claimed that by 1896 methods were still sufficiently rudimentary that effective and ineffective disinfectants could not be accurately distinguished.¹⁴⁴⁵ On the other hand, some were cautious that progress did not run away with itself. Moor and Tanner presented an especially cogent argument about the limitations of bacteriology.¹⁴⁴⁶ They claimed that assessing the efficacy of chemical disinfection was problematic as there was no clear understanding of how disinfectants actually worked on bacteria, and there was no theory that could connect all the facts. For this reason the whole understanding of disinfection was based on the results of experiments; as soon as an experiment changed the consensus, “the whole field was flung into disarray”.¹⁴⁴⁷ This reliance on empirical evidence without theoretical basis meant the whole field was unstable, and magnified the significance of testing methods above their true import. Practical experience was thus needed to redress the balance until an underlying mechanism was identified.¹⁴⁴⁸ Others backed this up and urged caution.¹⁴⁴⁹ This demonstrates that although bacteriology was vaunted as the best approach there

were significant calls for research to remain more grounded in practicality. These concerns over the usefulness of bacteriological testing were magnified in the debates about a standard method. As we shall see, the debates reveal an increasing gap between laboratory experiment and theoretical practice which undermined the usefulness of bacteriological research, and meant that statements about the certainty of the new knowledge were blinkered as to the failings of bacteriology.

Methods of testing disinfectants

As we have seen, new techniques were being developed and bacteriological testing became the preferred method. There was, however, significant variation in the conditions under which disinfectants were tested. By the 1890s, three main approaches had emerged from the morass of differing methods practised in the 1870s and 1880s. These differed significantly in their execution and results. Methods could be divided into two categories: those that allowed bacteria to be exposed to the full effects of the disinfectant, and those that encased the bacteria in some form of organic matter. The first category included the broth culture and drop methods, the second the thread and the garnet methods.¹⁴⁵⁰

The details of the techniques in the first category were as follows. The broth culture method entailed cultivating bacteria in organic solution then treating them with disinfectant.¹⁴⁵¹ The treated bacteria were returned to the culture medium, with the disinfectant removed; if the bacteria did not grow, then the disinfectant was assumed to be effective. Another similar method added cultures to known strengths of disinfectant, and at the end of a stated time a subculture was taken to see if the bacteria were dead.¹⁴⁵² The methods were simple, required little skill, and were popular.¹⁴⁵³ The drop method was similar in concept, but more complicated in execution. Sterilised water was infected with a small volume of gelatine containing bacteria. A specific volume of this water was then added to a disinfectant of known strength and left to act for a given time, then a drop of this liquid was then added to nutrient gelatine, where any re-growth was observed.¹⁴⁵⁴ The drop method was believed to be superior to the broth method as the addition of the drop of disinfected material to an excess of gelatine diluted any remaining

disinfectant and thus negated any ongoing antiseptic effects.¹⁴⁵⁵ Both methods could be problematic. The mixing of culture and disinfectant to a given dilution meant that the two reagents were much more effectively mixed than in dry disinfection, producing better results.¹⁴⁵⁶ More worryingly, both methods tested the action of disinfectants on “naked” bacteria, which were unprotected by organic matter or by drying. The presence of organic matter such as sputum or faeces could drastically reduce the effectiveness of disinfectants.¹⁴⁵⁷ In this way, the observed disinfectant action in these experiments did not reflect “real life” experiences.

The second category of methods took a completely different approach and involved the use of organic matter. The first of these was the thread method. This used threads or strips of cloth impregnated with bacteria.¹⁴⁵⁸ The thread was treated with disinfectant and soaked in sterilised water until all traces of the disinfectant had been removed. It was then added to a gelatine culture, where the growth of any remaining bacteria was observed.¹⁴⁵⁹ Another method mainly used on the continent was the garnet method.¹⁴⁶⁰ This technique, developed by Kronig and Paul, used cultures dried on garnets, which were then treated with disinfectant, washed and then transferred to broth cultures where the growth of the bacteria was observed.¹⁴⁶¹ These approaches tested the effectiveness of disinfectants on dried bacteria, providing a different and apparently more realistic set of conditions. The methods also overcome the dilution problems encountered in broth and drop methods.¹⁴⁶² Nevertheless, there were still concerns. The difficulty of adequately washing the test items was a problem in both methods, and both were unsuitable for any organism that was sensitive to desiccation.¹⁴⁶³ The thread method was also explicitly criticised as disinfectant retained in the threads continued to act on bacteria in the final culture medium.¹⁴⁶⁴ No method was ideal and there was little comparability between them. Whatever the method, experimental conditions did not reflect disinfection as it was actually undertaken.¹⁴⁶⁵ The whole relevance of laboratory

testing could be questioned on these grounds: if research did not fit the conditions of disinfection in practice, what use was it? These twin problems of method and reliability needed to be solved and attracted significant attention over the next decades.

Standardising Methods: Early Debates

Some concern had been expressed in the 1890s about the differences between methods. The disparity led to contradictory outcomes, and results could not be used to build up a sensible pattern of overall disinfectant efficacy.¹⁴⁶⁶ This tension erupted in 1900 when A. Burgess published research using the thread method. Although he had shown great consideration of methodological problems, his results caused controversy as they did not align with those produced by other approaches. He was criticised by a range of commentators including both Rideal and Ainslie Walker, who denigrated his method and urged the use of an improved one.¹⁴⁶⁷ This reflected a wider concern about the importance of exact experimental conditions. Kronig and Paul in particular considered the impact of variations in conditions on the effectiveness of disinfectants.¹⁴⁶⁸ Temperature, time of exposure and growth, the number and resistance of test bacteria, the presence of nutrient material in the trial, and the molecular equivalence of the quantity of disinfectant all needed to be taken into account.¹⁴⁶⁹ These conditions were frequently mentioned over the next few decades and there was general agreement about their relevance, although their complexity made deciphering any impact difficult.¹⁴⁷⁰ There were therefore calls for a standardised method which would remove the potential for error due to these factors.

Calls for standardised methods started in the 1890s, but gathered pace after 1900, fuelled at least in part by the emergence of several competing “standard” methods.¹⁴⁷¹ It is important to understand who was involved in the debate. Calls for standardised methods were made by bacteriologists and chemists in the main, but also by manufacturers, some medical professionals, and those interested in public health.¹⁴⁷² All these groups had differing interests and aims which affected their ideas and responses, as we shall see, and which contributed to the tenacity and complexity of conflicts. The

public, including the educated sections of the population, were notably absent. They were generally on the receiving end of debate and absorbed the information promulgated by different sources. Local authorities were also not involved, tending to utilise their own testing methods. The fact that the two groups undertaking the majority of practical disinfection were not involved is telling, and indicates one possible reason why the debate did not reflect their needs. The arguments put forward by those supporting standardisation were varied. The lack of consistency in methods meant that research could not be usefully compared, hindering the progress of scientific understanding. Improving disinfection in practice was also a key concern, as the range of disinfectants available, combined with the lack of legislation to control minimum standards, meant the public tended to use ineffective disinfectants.¹⁴⁷³ Indeed, the legislation introduced in 1900 and 1902 to curb carbolic poisoning had made things worse and “put a premium on inefficiency”.¹⁴⁷⁴ Authorities were also unable to guarantee that the disinfectants they purchased were effective.¹⁴⁷⁵ There was, therefore, a practical need to control the value of disinfectants, necessitating an agreed test.¹⁴⁷⁶ Without an accepted method these were, however, disparate calls for unspecified action.

The proposal of a particular method as the standard moved these debates forward. The Rideal-Walker method was developed in 1902 by chemists Dr. Rideal and Mr. Ainslie Walker.¹⁴⁷⁷ They had initially called for a general debate on testing and legal control of the standard of disinfectants sold, but then moved on to champion their own method.¹⁴⁷⁸ They claimed that the existing deviations in approach resulted from personal preference rather than genuine scientific differences, and that if a standard method was developed researchers would use it.¹⁴⁷⁹ This would promote genuine disinfectants, protecting consumers and the public health, and would thus be beneficial for manufacturers who were retailing an effective product.¹⁴⁸⁰ Their method aimed to address all the problems around disinfectant testing and standardisation.

The method was based on the broth culture approach. Five drops of a culture of B. Typhoses were added to 5 cubic centimetres of a known concentration of disinfectant in

sterilized water, then subcultures were taken between 2.5 and 15 minutes. The cultures were then left for 48 hours at 37 degrees Celsius and the results observed. The effectiveness of the test disinfectant was compared against carbolic acid and accorded a “carbolic coefficient” which showed how much of the disinfectant was needed to achieve the same result as using carbolic.¹⁴⁸¹ This could be used to calculate the comparative real costs.¹⁴⁸² The method aimed to provide homogenous conditions and thus produce universally comparable results.¹⁴⁸³ There was initial praise for the method’s “simple and ingenious” nature, and its “efficiency and accuracy”.¹⁴⁸⁴ The method, although never wholly accepted, rapidly became popular and it was often the only approach textbooks discussed.¹⁴⁸⁵ By 1909, it had become the most popular form of bacteriological test for disinfectants.¹⁴⁸⁶ This drive for a standardised method demonstrated the desire of doctors and other professionals to have a comparable method which would allow them to make sense of the increasingly large and complex literature on the topic.

Other bodies agreed on the need for standardisation and took up the Rideal-Walker method. The institution of the Rideal-Walker test made it possible to buy disinfectants according to their germicidal value, the relative cost being calculated from the efficacy versus price.¹⁴⁸⁷ Tenders could then be asked for on a carbolic acid coefficient basis meaning that all manufacturers could tender on an equal footing.¹⁴⁸⁸ This was taken up by government departments. In 1904, the War Office had stipulated that contractors supplying disinfectants should test them on the bacillus typhosus, taking carbolic as the unit of comparison, and they stated a minimum carbolic coefficient value.¹⁴⁸⁹ By 1908, the test had been adopted by the Admiralty, and other government departments as well as municipalities and other authorities.¹⁴⁹⁰ Standardisation was thus an important and increasing concern for a range of authorities, and, although not universally applied, was used to ensure that they received value for money.¹⁴⁹¹ The debates about standardisation illustrate wider points underlying the victory of laboratory

knowledge. This was aided by the development of professional groups who laid claim to expert knowledge inaccessible to lay people, and also by the rise of industry with its “new premium on deterministic causal laws in theory and technical control in practice”.

¹⁴⁹² The standardisation debate drew on this claim to expert knowledge, as disinfectants were to be tested in ways that were beyond the expertise even of most medical professionals. All those who were not bacteriologists were excluded from the knowledge needed to control disinfection; the dispute over laboratory methods can be read as part of a wider conflict between bacteriological and medical forms of professional knowledge and their role in controlling infection.¹⁴⁹³

Standardisation was also of importance to manufacturers. They were often eager to see standardisation implemented, although they were concerned about how it would progress.¹⁴⁹⁴ Whilst manufacturers wanted to make money, they were also convinced of the worth of their products; standardisation could validate or undermine their position depending on the method. Several manufacturers felt that the lack of a standard method disadvantaged them as it meant they had no measure of effectiveness they could use in their advertisements to distinguish their products from others.¹⁴⁹⁵ By 1907, there was apparently agreement among manufacturers and chemists on the reasonableness of applying a germicidal test to the disinfectants sold.¹⁴⁹⁶ The motive of profit, however, meant that some companies opposed the Rideal-Walker method. Manufacturers had long criticised research which did not show their products in a positive light.¹⁴⁹⁷ The response to the Rideal-Walker method was, nevertheless, more pronounced than any previous movement. The McDougall Brothers complained that the method was unfair, and disadvantaged their products.¹⁴⁹⁸ The Sanitas Company was also opposed to various forms of standardised testing on the basis that they underestimated the disinfectant power of their product because leaving a disinfectant emulsion to stand and settle underestimated its power.¹⁴⁹⁹ Mr. Kingzett frequently criticised the Rideal-Walker method throughout the period from 1900 onwards.¹⁵⁰⁰ Even the manufacturers of Izal,

not generally outspoken on the topic, were unhappy with the method.¹⁵⁰¹ Manufacturer support for the method was at best transitory. Companies called for an independent committee to be appointed to consider the issue.¹⁵⁰² This was unlikely to have satisfied all complainants; the Sanitas Company criticised other methods, such as *The Lancet* method, as its similarity to the Rideal-Walker method meant it also undermined Sanitas.¹⁵⁰³ This could not, however, entirely conceal the fact that the product's poor performance could reflect unsuitability for general use.¹⁵⁰⁴ An intended, but unwelcome, consequence of new testing could be the discrediting of ineffective disinfectants. It should, however, be noted that most companies were not hostile to research as they were eager to find a method that benefited their product. Many companies therefore continued to commission their own research instead of or alongside the Rideal-Walker method.

Izal provides an interesting example of the complexities of this relationship. The Izal company contracted a number of researchers to prove their products' effectiveness throughout the 1890s.¹⁵⁰⁵ These included Professor S. Delepine, a famous researcher and Professor of Pathology at the Victoria University of Manchester and A. Wynter Blyth, a famous MOH and researcher, and their work achieved positive results.¹⁵⁰⁶ This use of experts was common, with other disinfectant companies employing various bacteriologists and chemists as independent advisors.¹⁵⁰⁷ This does not seem to have jeopardised their independence, especially given that their research was not always accepted by the firms. The employment of experts by disinfectant companies nevertheless attracted scorn, and the commercial entanglements of figures such as Walker reduced their legitimacy.¹⁵⁰⁸ Izal boasted about their use of professional bacteriologists and used this in their advertising material. Evidence from 1913 showed that they were using a standard method, although it was not the Rideal-Walker method.¹⁵⁰⁹ An interest in testing therefore did not translate to support for the method.

In some cases companies supported the Rideal-Walker method, usually if it was favourable to their product. The Jeyes Company backed several methods at various times.

¹⁵¹⁰ The Company also had an ongoing relationship with leading bacteriologists. Both Rideal and Walker had worked for the company, and Mr. Walker had become managing director by 1905. They also appointed Dr. E. Klein as scientific advisor and used other scientists to test products.¹⁵¹¹ The use of these experts was criticised by other firms, forcing the Jeyes' owners to defend themselves. They saw no conflict of interest in the two roles, and criticised any ideas that Walker's commercial interests incapacitated him as a bacteriologist, or made them or him dishonest.¹⁵¹² They finished by defending themselves, claiming that they were reliable and honest vendors of disinfectants, and that a better method than the Rideal-Walker test needed to be devised. Inter-firm rivalries led to convoluted disagreements which increasingly incorporated criticisms of the Rideal-Walker method. Nevertheless, they did also, on occasion, back it.¹⁵¹³ The carbolic coefficients of all the company's products were verified by the Rideal-Walker method before the products left the factory.¹⁵¹⁴ The carbolic coefficient values also appeared in advertisements.¹⁵¹⁵ Companies were often willing to hedge their bets and adopt different methods despite their support for a standard method. In this way, companies could have diverse viewpoints on testing yet still use it as a method to promote their products; if they did not they risked being left behind. Testing was remade as a positive process whereby companies promoted their products, as well as a means for the public and authorities to protect themselves against manufacturers. Nevertheless, there were still problems with standardisation.

Criticism, debate and the Rideal-Walker method

The Rideal-Walker method was the most popular standardised test but it continued to face criticism.¹⁵¹⁶ Some stated that the conditions of the method were troublesome. Authors criticised the choice of a single test organism, the use of *B. Typhoses*, and the use of the same volume of sub-sample no matter what the concentration of disinfectant, meaning the effects of strong disinfectants were overstated.¹⁵¹⁷ These decisions could concern even those who identified positive aspects of the

method.¹⁵¹⁸ More importantly, commentators doubted its usefulness for guiding practical disinfection. The Rideal-Walker method was repeatedly criticised as not replicating reality.¹⁵¹⁹ In particular, the test did not present disinfectants with bacteria encased in obstructive organic matter, but instead gave the easier challenge of killing “naked” bacteria.¹⁵²⁰ Notter and Firth claimed that this was the main objection to, and drawback of, the method.¹⁵²¹ Those who were attempting to use the methods also found this to be a problem. A series of articles in 1906 illustrated that discussions over whether electrolytic disinfectant was effective hit a stumbling block over whether testing replicated the organic matter encountered in practice.¹⁵²² For this reason, various commentators urged a margin of error to account for this “germicidal incompatibility” when recommending disinfectants for practical use.¹⁵²³ Others went further, requesting that new conditions were added to the test itself to take into account these problems. Other practical issues were also considered: for instance, the difference between hard and soft water was regarded as an influence over the effectiveness of disinfectants.¹⁵²⁴ Other factors, such as the temperature the tests were undertaken at also had an impact on the observed results.¹⁵²⁵ Various practical factors not covered by the Rideal-Walker method therefore continued to be raised as criticisms and limitations of the method even after it had passed into widespread use. The notion that bacteriologists would simply accept any standardised method that was presented to them proved untrue.

These debates highlight a fundamental problem, namely the gap between the aims and capabilities of laboratory methods. Sheridan Delepine identified the heart of the problem. He thought that the Rideal-Walker method represented a chemical approach to disinfection, which had been pursued by Rideal and Walker, Kronig and Paul and others. This approach prioritised finding out the definitive value of a disinfectant’s action on germs, and put far less emphasis on the practical use of the substances. On the other hand, public health researchers such as John Simon, Robert Koch and Dr. Baxter had pursued a “hygienic” approach which had attempted to assess the value of disinfectants in practice.¹⁵²⁶ These approaches had very different goals, and research from one area

could not be easily applied to another.¹⁵²⁷ This viewpoint was backed up by Hibbert. He claimed that new research was based on chemical laboratory work, not on practical medical research, with resulting confusion.¹⁵²⁸ Medical men only had themselves to blame for neglecting to develop a culture of medical bacteriology.¹⁵²⁹ Whilst few authors identified this as the root cause of disagreement it does indicate the differences in how professions approached public health problems. The standardisation debate was another manifestation of tensions over who had appropriate authority in preventative health.

Some of the disagreement over methods thus came from disagreements over what a method should be expected to do: should it represent laboratory comparisons, to give as close as possible to an “absolute” value as possible, or should it give a guide for disinfection practice? Different commentators stated different things.¹⁵³⁰ Rideal and Walker elided the two concerns together. On the one hand, Sommerville and Ainslie-Walker stated that the Rideal-Walker method was intended to show the comparability of disinfectants under specific conditions, rather than in practice.¹⁵³¹ The adjustments they made to their method concentrated on improving chemical and bacteriological practice in the laboratory, rather than making the changes that would give the method direct practical applicability.¹⁵³² In this way, they clearly set assessing the practicalities of disinfection aside as something to be pursued after disinfectant efficacy had been established.¹⁵³³ Nevertheless, Rideal and Walker responded to some of their critics by defending the validity of their method both as a laboratory test and a practical guide. Their initial statements on the method also show that it was developed with practical application in mind, and their followers believed that it would help to improve practice.¹⁵³⁴ The limits of the method’s applicability were unclear and this tension between aims of comparability and scientific robustness, and practicality and applicability to real life was not fully worked out. Two separate sources of contention were thus evident in the standardisation debates. The first centred on setting out the conditions, such as culture medium, temperature and number of bacteria used in the laboratory and standardising them to

allow results to be compared. Although there were different opinions on which values were to be chosen, these debates were about deciding on a common process. On the other hand, debates about the applicability of disinfectant testing also intended that a common approach should be determined, but that this should be one which accurately replicated the conditions found in normal disinfection. Laboratory methods thus aimed to reflect real practice, albeit a standardised one, but were not able to overcome some of the fundamental problems posed by the artificial conditions they tested disinfectants under.

With the Rideal-Walker method gaining ground and popularity, the issue of settling the disputes about it became more acute.¹⁵³⁵ The Royal Sanitary Institute therefore appointed a committee in 1903 to examine the issue of standardisation.¹⁵³⁶ The Institute, set up in 1876, was a society for those with an interest in public health and the certification body for Inspectors of Nuisances. The Society attracted members from all areas of preventative medicine and had many members who were regarded as experts, so it had always seen “the investigation of hygienic appliances, methods and procedures and the issuing of reports for the guidance of public authorities and the public” as one of its most important functions.¹⁵³⁷ They considered standardisation of disinfectants important enough to investigate, showing its role in public health at this time. The committee met numerous times and debated the issues at length.¹⁵³⁸ The report, delivered three years later in 1906, concluded that although no single method could test the behaviour of disinfectants in all conditions the simplicity of drop methods, of which the Rideal-Walker method was one, made them suitable for general use.¹⁵³⁹ Where special conditions such as the addition of organic material were required the customer commissioning the tests should request them specifically.¹⁵⁴⁰ They therefore recommended the Rideal-Walker method for general analysis.¹⁵⁴¹ This put forward a strong message in favour of the method, and shows the committee making a specific distinction between laboratory conditions and conditions that replicated practice. Nevertheless, there were problems. The report was never officially adopted by the Institute or published by them, although the results were widely reported in the press.

¹⁵⁴² It could be deduced from this that committee was not unanimous in supporting the findings.

Whatever the cause of this uncertainty, the lack of legitimisation led to conflicting statements about the level of support that the committee had shown for the method.¹⁵⁴³ Even expert opinion could not agree on a suitable method of testing disinfectants. These differing expert opinions are similar to those found by Hamlin concerning water purity. Hamlin showed that the use of germ theory in debates about water quality, although it seemed ‘successful, progressive and even revolutionary’, was sufficiently imbued with controversial issues that when it became involved with the politics of water quality it could no longer provide an independent source of advice.¹⁵⁴⁴ Macleod has argued that lack of agreement on a scientific standard due to lack of knowledge was a serious impediment to management of fish stocks.¹⁵⁴⁵ On the other hand, MacLeod has also shown that where a necessary “scientific” standard and method of control could be agreed on implementation could proceed relatively easily.¹⁵⁴⁶ The standardisation debate had enough points of scientific disagreement to make its impact unstable, and the lack of a scientific standard hindered how it could be put into practice.

The controversy showed no signs of abating over the next few years, while the debating of the issue in Parliament in 1908 provoked further contention in some quarters. To further complicate matters, the garnet method had become popular on the Continent, adding another facet to the issue.¹⁵⁴⁷ How did the professions react to this ongoing debate? The general climate remained positive about the idea of standardisation.¹⁵⁴⁸ Consensus was nevertheless not forthcoming.¹⁵⁴⁹ Positive messages about the Rideal-Walker method continued and the authors promoted it, demonstrated it at the London School of Tropical Medicine in 1908, and pointed to its adoption by the Sanitary Institute as a recommendation of its usefulness.¹⁵⁵⁰ Foreign authorities also adopted the method.¹⁵⁵¹ Rideal built on this and claimed that his method had been the standard for many

years and had been approved by the Sanitary Institute.¹⁵⁵² These arguments did not entirely find favour with the wider profession. *The Lancet* tartly pointed out that the Sanitary Institute report was never formally adopted.¹⁵⁵³ Wynter Blyth also weighed in, claiming that since the Institute had refused to approve the report, yet had still produced it, it could not be claimed that they either approved or disapproved of the method.¹⁵⁵⁴ Rideal and Walker's claims were not taken at face value.

Nevertheless, other authors supported the method and it, alongside the variants which had developed, remained the most commonly recommended approach.¹⁵⁵⁵ An article in *Public Health* in 1907 claimed that the only method studied and published to any extent was the Rideal-Walker one, and that this should be used.¹⁵⁵⁶ Authors were also concerned about the adoption of "capricious" variants on the Rideal-Walker method which threatened to drag the debate back to the period before standardisation. Several articles counselled that these should be avoided, and that such approaches could undermine the legitimacy of bacteriological methods.¹⁵⁵⁷ The method continued to be supported by some while others saw it as a stepping stone to the development of better tests.¹⁵⁵⁸ Indeed, the very contention that the Rideal-Walker method gave reliable results and was thus a suitable standard method began to be questioned.¹⁵⁵⁹ Rideal defended his test, claiming that variation of results hardly indicated the need for a more complicated test to be introduced.¹⁵⁶⁰ This unreliability was, however, problematic for a standard method, and shows the extent to which it did not provide comparability.

Concerns about the specifics of the Rideal-Walker method nevertheless continued to appear, as did comments about the lack of organic matter.¹⁵⁶¹ Several authors saw it as a crucial addition to the method, and one without which the Rideal-Walker method could not be useful.¹⁵⁶² The addition of substances such as milk or faeces had therefore been suggested.¹⁵⁶³ Many supported a powdered faeces method devised by Miss H. Chick; this was seen as the most promising of the emerging methods.¹⁵⁶⁴ Use of such

methods vindicated concerns as these experiments found the coefficients to be about half as high as observed with the Rideal-Walker method.¹⁵⁶⁵ There was, however, no way to standardise the tests on organic matter.¹⁵⁶⁶

Some took this further and claimed that bacteriological tests alone could not be used for standardisation, as there were such differing results even with the same method.

¹⁵⁶⁷ Others argued that one bacteriological method could never adequately judge all disinfectants across all circumstances, and thus a range of methods needed to be used according to the type of information sought or conditions desired.¹⁵⁶⁸ Rideal agreed with this position; this reinforces the impression that although he thought his method could be useful, he did not approach it in the same way as those who complained about its lack of practicality. There were also suggestions that bacteriology was actually undermining the need for disinfection in general as it showed that most infections occurred from direct contact.¹⁵⁶⁹ Practical experiments were also undermining the

necessity of some forms of disinfection.¹⁵⁷⁰ The increased focus on testing thus ran the risk of undermining disinfection rather than pointing to which methods were effective. Variations in the methods available thus led to continued debate about the effectiveness of the Rideal-Walker method.¹⁵⁷¹ Some, including *The Lancet*, Wynter Blyth and the North-Western Branch of the Society of Medical Officers of Health, therefore called for independent scientific verification.¹⁵⁷² Nevertheless, despite these calls for independent inquiry and practicality, by early 1909 the Rideal-Walker method remained the only

method that has been put forward, widely used and the results studied.¹⁵⁷³ The debate seemed to have stalled. Frustration is evident in some publications. In 1909, *The Chemist and Druggist* wearily claimed that the difficulties encountered in deciding upon a standardised testing method seemed even greater than those encountered in the standardisation of drugs.¹⁵⁷⁴ They themselves believed that none of the chemical or bacteriological methods so far used were suitable for all circumstances, and that a new

method needed to be sought.¹⁵⁷⁵

In the midst of the confusion, manufacturers, several members of the 1903 Sanitary Institute committee, and *The Lancet* itself called for independent research, stressing that although the Rideal-Walker method was useful more work was needed as it came to differing results.¹⁵⁷⁶ *The Lancet* therefore appointed its own committee in 1909, aiming to settle the dispute once and for all.¹⁵⁷⁷ They justified the move on several grounds. As disinfection was redefined as germicide, definite knowledge on which agents were useful should have been forthcoming. The lack of a standard test with universal support that accurately reflected practice had hindered this and threatened public health.¹⁵⁷⁸ The whole issue had been in an unsatisfactory position for years and the state had made no effort to control the standard of disinfectants and protect the public against ineffective preparations.¹⁵⁷⁹ They had therefore appointed a commission to examine the facts and try to come to some conclusions. Rideal, however, saw the appointment as a partisan move prompted by Wynter Blyth, Dr. Sims Woodhead and Dr. Constant Ponder, who were biased towards chemical method.¹⁵⁸⁰ Personal and professional rivalries were invoked as sources of disagreement.

The commission reported back in November.¹⁵⁸¹ They concluded that the Rideal-Walker method had some merit, but was unsuitable as the standard method unless seriously modified as it was inconsistent and was not practically applicable.¹⁵⁸² Their results found coefficient values significantly lower than produced by the Rideal-Walker method, indicating that the germicidal abilities of many disinfectants had been overstated.¹⁵⁸³ Many other methods were also discredited.¹⁵⁸⁴ With the field open *The Lancet* put forward its own directions, which were a modified version of the Rideal-Walker method. They changed the test organism to *bacillus colli communis*, and made minor alterations to timing, culture method, culture type and other practical factors.¹⁵⁸⁵ They did, however, recognise that bacteriological tests were too narrow to include all the factors that affected

the bactericidal powers of disinfectants.¹⁵⁸⁶ Research on the use of disinfectants in the conditions that they would face in practice was felt to be needed, with the aim that a multiplier could be found to convert laboratory results into a guide for practice.¹⁵⁸⁷ Chemical tests could add to this knowledge and provide much needed direction on the value of disinfectants under certain conditions.¹⁵⁸⁸ Bacteriological tests were to provide grounds for comparison but needed supplementation before they could be used to show the effectiveness of disinfection in practice. Much work remained to improve bacteriological tests to the point where practical disinfection would have reliable data as a foundation and the problems would be solved.¹⁵⁸⁹ The question of practical disinfection was not as simply answered as that of germicidal activity.¹⁵⁹⁰ Despite this concern the focus on bacteriological testing was maintained.

The reaction to *The Lancet* report was mixed. Rideal and Walker unsurprisingly defended their method, pointing to the 1903 Sanitary Institute report as the definitive statement on the matter.¹⁵⁹¹ In their defence, *The Lancet* claimed, not unfairly, that the previous Committee had not settled the debate.¹⁵⁹² There were, however, other detractors. *The Chemist and Druggist* was unconvinced, and articles concerning the topic in this journal were generally hostile.¹⁵⁹³ This stemmed in the most part from the notion that *The Lancet* had ignored knowledge already collected by chemists and druggists about the power of disinfectants.¹⁵⁹⁴ Professional rivalries could undermine a move towards standardisation. Several manufacturers were also concerned about particular details of *The Lancet* testing method.¹⁵⁹⁵ Predictably, Mr. Kingzett of the Sanitas Company objected to the testing method for several reasons, chiefly that it underestimated the value of emulsified disinfectants including Sanitas.¹⁵⁹⁶ He also launched into a tirade, claiming that he “resented” and “dissented” from the definition and thought other factors apart from germicidal ability should be considered.¹⁵⁹⁷ Kingzett’s views were idiosyncratic and did not reflect widespread opinion. They do, however, show the

vehemence with which manufacturers could oppose testing. *The Lancet* responded to these letters with veiled annoyance and rather pointedly stated that they welcomed comments from manufacturers who had a theoretical or practical knowledge on the subject and would pass on the letters to the commissioners.¹⁵⁹⁸ They reiterated that they had no bias against any manufacturer and were only concerned about arriving at the true facts of the case.¹⁵⁹⁹ In saying this, they were implicitly criticising the manufacturers whose pre-eminent concern was for their own products and profits, rather than effectiveness. *The Lancet* method attempted to provide improvements that arrived at the “true facts”, but it was not universally acceptable. Despite its apparent advantages, *The Lancet* method does not seem to have become widespread, and the Rideal-Walker method continued to be discussed and referenced as the most common way to test disinfectants. In this way, although the Rideal-Walker method remained popular even after significant challenges and alternatives, there were still interested parties who had not been satisfied by the discussions that had already occurred, and were looking for new approaches.

The debates rumbled on into 1910. On the conceptual side commentators continued to point out the problems of developing a testing method that was fair and scientific, and that avoided the various pitfalls already described.¹⁶⁰⁰ The weaknesses of existing theories were also highlighted. Delepine argued that the understanding of disinfectant theory was weak enough to prevent any “mathematical” understanding of their powers.¹⁶⁰¹ A standard method was only an ideal. The problem of applying a laboratory method to practice was also re-stated.¹⁶⁰² The British Pharmaceutical Conference, held in August 1910, thought that no chemical or biological process had received full consideration of these necessary conditions, although existing methods had given good comparative results.¹⁶⁰³ Despite these ongoing concerns, standardised methods continued to be promoted. Dr. Sims Woodhead and Dr. Constant Ponder claimed that comparisons and deductions had to be made in order for progress to be made.¹⁶⁰⁴ All the problems and controversy had not destroyed faith in a scientific standard. In practice a range of testing methods continued to be used. The Rideal-Walker method

continued as usual. *The Lancet* and *The British Medical Journal* also continued to report on *The Lancet* method, and the method was also taken up by some manufacturers.¹⁶⁰⁵ A standardised method seemed even further away.

The publication of a new method of testing, developed in the United States by Anderson and McClintock, reignited debate in 1911.¹⁶⁰⁶ The authors were unsatisfied with both the Rideal-Walker and *The Lancet* methods.¹⁶⁰⁷ The new method was a hybrid of the two and aimed to get more consistent results.¹⁶⁰⁸ The publication of the research set off another flurry of articles discussing modifications to *The Lancet* method and disinfectant testing more generally.¹⁶⁰⁹ *The Lancet* reacted well, welcoming the criticisms and development of their method.¹⁶¹⁰ A third method, developed by Dr. Martin and Miss Chick at the Lister institute, was also highlighted.¹⁶¹¹ This method had been in development for several years and then started to come to the fore from 1909 onwards.¹⁶¹² This method paid strict attention to the exact conditions, using 3% of dried faeces in broth culture rather than broth culture alone; this was its main selling point and aimed to remove the problems associated with a lack of organic matter.¹⁶¹³ The method was poorly received by Rideal, who claimed that it was an unhelpful compromise between laboratory and practical conditions which did not really represent either.¹⁶¹⁴ Other commentators were also unimpressed, stating that it did not really matter what the details of the method were as long as it was something consistent that would indicate the relative value of different disinfectants.¹⁶¹⁵ Criticism of the new method thus continued to blur the lines between ensuring standardised practice in the lab, and that this standardised practice took account of practical conditions.

The debate over which method to adopt was continued at the Fifteenth International Congress of Hygiene in 1912, and into 1913.¹⁶¹⁶ By 1913, the Anderson and McClintock method had become the standard in America, demonstrating international differences in which “standard” tests were adopted.¹⁶¹⁷ Others were,

unsurprisingly, unwilling to accept the new ideas. Rideal was opposed to the method, thinking it too complicated, and continued to urge that his method be used; until a basic standard method was universally agreed on, then adding other conditions such as organic matter was futile.¹⁶¹⁸ Whilst this highlights his partisan attitude, it also shows the ongoing blindness to the difference between laboratory and practical usefulness. The Rideal-Walker method continued to hold the field in England, was used by many authorities, and was well regarded.¹⁶¹⁹ This perpetuated confusion and discussion about which method was best. Some continued to believe that no method proved the action of disinfectants in practice.¹⁶²⁰ Others, however, held out for one that would compare disinfectants in practice and provide a basis for legal control of disinfectant strength.¹⁶²¹ The Congress therefore sought to end the debate and to develop a simple bacteriological test everyone could agree on; given the importance of formulating a thoroughly satisfactory standard the Congress had appointed a committee to consider the matter once again.¹⁶²² *The Lancet* welcomed the resolutions as there was still a divergence of opinion on which laboratory tests should be used. They thought that their own method, published three years earlier, had reduced error in testing and given a fair test but were also willing to countenance new methods.¹⁶²³ The Committee deliberated throughout 1913 but did not come to a definite conclusion by 1914.¹⁶²⁴ Despite over a decade of detailed debate, research and controversy, no standard method of testing disinfectants had been found. Commentators had been unable to agree on either a standardised laboratory-based method, or on a method that incorporated practical aspects. Bacteriology had thus significantly enhanced the ways in which disinfectants could be tested, but had not provided the new, clear disinfectant standards that some researchers had initially hoped for.

Conclusion

The failure to adopt a standardised method for testing disinfectants demonstrates a number of important factors about the relationship between germ theory, disinfection and practicality. The first point is that disinfectant testing was practiced before germ theory,

and that non-bacteriological methods continued to be used throughout the period. Testing the effectiveness of disinfectants was not solely a germ practice. Nevertheless, germ practices did have a significant effect on disinfectant testing and provided a break with the past in the way disinfectants were tested. Contemporaries believed that bacteriological testing of disinfectants provided a reliable way of assessing their value, and that the hierarchy of reliable methods had been revolutionised by these new approaches. In some ways their views were reflected in the development of methods; as Chapter Three has shown, bacteriology could overhaul practical disinfection advice and change the hierarchy of recommended disinfectants. Nevertheless, this did not necessarily result in changes in the practice of disinfection. Furthermore, the continued debate over a suitable method for testing disinfectants demonstrates that germ theory did not solve all the questions about the effect of disinfectants on bacteria. The ongoing and significant controversies over the exact conditions needed to test disinfectants demonstrate the problems of reaching a standardised method. Different groups had varying perspectives on the issue according to their preoccupations and bias, and backed approaches based on these views. Although commentators agreed that a standardised method was needed, they could not agree on whether this should be standardised to a reasonably defensible laboratory method that did not necessarily reflect actual practice, or whether methods should concentrate primarily on representing the conditions found in practical disinfection. The complexities of the debate and the disagreements between “experts” show that whilst there was no clear way forward, British opinion coalesced around an option which could fulfil some of the desired characteristics, namely the Rideal-Walker method. These debates, however, did not solve the problems faced by local authorities in practical disinfection. The ways in which disinfectants were evaluated increasingly diverged from practice, and meant that research was unhelpful for those responsible for practical disinfection. For disinfection research, germ theory offered the possibility of more solid knowledge, but actually brought confusion rather than clarity.

Chapter Eight: Conclusion

This thesis has examined the development of disinfection policy in England, c.1840 to 1914. It has illuminated a previously unexplored area of nineteenth century health and medicine, adding to the understanding of public health policy and practice in this period. The implications

are wide-ranging, and illuminate a number of ongoing historiographical debates in public health history and social history generally. As with any pioneering study of a major topic there is, nevertheless, scope for further research to extend understanding. The methodology used here has produced interesting results, and is a suitable means for further investigation. Examining nineteenth-century literature, making use of modern I.T. through keyword searches, has proved a fruitful way to find a wide range of relevant materials. The use of comparative local case studies helped to link the literature to real-life examples, and highlight the complexities of local authority disinfection practices. The relative silence on disinfection in the local primary sources was, however, an unexpected drawback; any further work in the future would have to take this into account and explore a wider range of case studies. More detailed work on the factors affecting policy at local level would be beneficial, as would an examination of case studies in other areas of the country to confirm whether the towns examined here were typical. Further study of the legislative and commercial aspects of disinfection could also provide a more nuanced picture. The work presented here has, however, highlighted many interesting aspects of disinfection. This conclusion aims to draw out the most significant themes, showing the contribution that this work has made to the overall understanding of the topic and the history of the public's health more generally.

Germ theory, disease causation and the theory and practice of disinfection

Contrary to contemporary assumptions and some historiographical assertions, disinfection was not solely a germ practice. As Baldwin has argued, disinfection drew on much older and more varied approaches to health, and could be fitted into most systems of disease prevention.¹⁶²⁵ This thesis builds on this idea and shows the complexities of the development of concepts of disinfection.

Processes of disinfection were not static, but adjusted to whatever definition of "infection" was dominant. The fluidity of definitions in the first half of the century is striking, especially when interactions with other processes, such as disinfection of wounds, antiseptis and disinfection of sewage are considered. The number of disinfection agents was, however, markedly more limited than later in the century, although most suggested disinfectants were accepted as such with relative ease. The range of items and locations targeted was also fairly tightly bounded, concentrating on things which were regarded as the most likely modes of transmission. This could be very close to the measures used later in the century. Orders from the 1866 cholera outbreak recommended many of the same measures as those from the 1890s.¹⁶²⁶ The evidence

presented here also underlines that many of the elements incorporated into “public health disinfection” after 1870 were already in place by the 1850s. House disinfection, heat disinfection of clothes, and the use of chemicals were all utilised during epidemics and on particular sub-populations from the 1830s onwards, and were increasingly deployed as routine measures thereafter. Local areas were not exempt from this, and all of the local case studies undertook some form of disinfection, albeit to a limited extent. The focus shifted as the century progressed. The 1866 cholera and cattle plague outbreaks highlighted the need for disinfection at national level, and presaged attention on disinfection within a system of ‘stamping out’. There was a system of disinfection in place in many areas, although a somewhat rudimentary one, long before germ theory was developed, let alone accepted. Disinfection was well integrated into the fight against disease throughout the century. Contrary to some historiographical comment, there was also relatively high confidence in disinfection in the first half of the century, provided it was used alongside methods which rectified underlying health problems.¹⁶²⁷ There was an increasing focus on disinfection from the 1840s onwards, and the development of a skeletal approach which, although fleshed out, remained largely unchanged throughout the rest of the century. This represents a major reassessment of the early agreed validity of disinfection, demonstrates the relative unimportance of germ theory in the widespread establishment of disinfection as both a concept and a practice, and highlights the continuity in day-to-day disease prevention methods across the century.

Nevertheless, though germ theory did not create disinfection it did re-create it. The advent of germ theory can be seen not as an originating cause but as a watershed in the history of disinfection. Worboys has argued that disinfection was remade as a germ practice, and increasingly was defined as germicide.¹⁶²⁸ This thesis supports this and shows that new theories did have significant effects on disinfection, and changed the standards by which disinfectants were evaluated. Ultimately disinfection became redefined solely as “germicide”, excluding the other functions, such as antiseptics and deodorisation, which were included before the 1860s and 1870s. This process was essentially complete by the 1890s. Whilst disinfection had been remade, this had worked by altering the concept of infection used within definitions, namely replacing wider concepts of “infection” with germs. This had thus operated in the same way as earlier changes to the conceptualization of disinfection such as those which replaced an emphasis on miasmas with focus on putrefaction, showing the elements of continuity in how changes to disinfection theory were enacted.

Alongside this, the number of disinfectants available increased rapidly, fuelled by chemical innovation and commercial development. New methods for the main disinfection processes were also developed, widening the possibilities. This proliferation necessitated more sophisticated ways of deciding which disinfectants were effective, and was linked to developments in bacteriological research. Gradually, a more systematic and “scientific” understanding of the mechanisms underpinning disinfection emerged. New methods of testing were developed which could show the direct effects of disinfectants on germs, replacing earlier methods which relied on epidemiological observations. These tests revealed the fragility of both traditional and novel attempts to kill germs and undermined many established disinfection methods. Many saw this as a way to improve practice, and reveal a type of disinfection “truth” that was able to prevent disease.¹⁶²⁹ This, combined with increasing understanding of possible means of transmission, rendered advice more specific and detailed, and “ideal practice” more exact. This confidence in standards of effectiveness, provided disinfection was carried out properly, was reflected in legislation and advice that increasingly recommended municipal, medically supervised disinfection. These debates assumed that MOsH would be implementing up-to-date, scientific policies, using their authority to ‘sell’ them to local authorities. The important role of authority and science in these debates is clear. This pattern of disinfection would bolster isolation and notification, and “stamp out” disease. Indeed, disinfection seems to have been able to fight infection directly, together with other policies, and by raising awareness of the necessity of cleanliness and combating infection. Many contemporaries were confident that this knowledge meant disinfection had become a scientific process and was, consequently, much more effective than in the first half of the century.¹⁶³⁰

These hopes did not translate smoothly into action, however. Disinfection in the first half of the century, whilst castigated as “ineffective” by later standards, had been accepted without intense debate. There were clear pathways to achieving acceptable disinfection both for the professionals involved and the public. As the century progressed, however, there was increasing doubt as to which methods should be used to optimize outcomes. Although agreement on a hierarchy was elusive there was increasing practical and laboratory-based evidence that some disinfection methods were more effective than others, making discernment between them important. The dizzying range of choices and divergence in advice increased diversity in practice, worrying contemporary commentators. This highlights power struggles between professions and groups, and the shifting patterns of allegiance thus created. New methods of testing aimed to

eliminate this uncertainty and the possibility of unsafe and ineffective disinfection. Researchers updated their methods of enquiry and used direct laboratory observations of disinfectants' effects on germs as a proxy for their claimed effects in all practical situations. There were nevertheless disagreements on the correct objectives of such research and how best to achieve them. Furthermore, the increasingly acknowledged differences between laboratory conditions and those met with in the more complex and uncontrollable world of practice stymied attempts to link the two, and diverted researchers into academic disputes over ensuring comparability of results. This meant that there was little progress towards a standard method by 1914, and also little advance in any definitive knowledge. Disputes over prioritisation, and control were key factors within this; this contradicted assumptions that new scientific theories had established a clear benchmark of truth. Whilst germ theory appeared to offer hope of agreement on standard practice, in reality the debates increasingly stalled due to disagreement on whether experimental results reflected an abstract scientific absolute or practical advice. The inability to adjust testing to the stated aim of helping disinfection practice was a serious drawback. This, alongside other factors, meant that disinfectant advice was only partially affected by changes in the estimated worth of various methods subjected to 'scientific' tests in the laboratory. Disinfection, science and authority: the professional role of MOsH

There were problems in putting the new research into action. Local MOsH were responsible for the increasingly wide programme of disinfection measures. This owed much to older disease-prevention measures which pre-dated both germ theory and the legislation promoting disinfection; local authorities had chosen and used their methods long before the research reassessed them. Crucially, the new research did not provide information that necessarily served the interests of local MOsH and the authorities they worked for. MOsH, who were thought to offer more effective approaches to disinfection, were actually very conservative, and prioritised proven practical methods, even where they were at odds with those recommended by the latest research. Indeed, most methodological changes that were made at local level happened where germicidal efficacy corroborated with other concerns. For example, steam disinfection was easy to adopt both in theory and locally as it satisfied the demands of efficacy and protected property. Where matters of practicality and acceptability diverged from those of effectiveness, however, practicality usually won out.

This did not mean that local areas were unwilling to change their policies. The case studies explored show that towns were communicating about new approaches, taking ideas from national policy and publications and putting the ideas of MOsH and experts into practice.

Successful disinfection depended on the interaction of a complex range of factors, which operated in different ways in varying locations over time. In this way, the authority given to MOsH, which seemed to rely on their perceived ability to implement new “scientific” disinfection, was not always applied. The lack of detailed consideration of issues of practical applicability, and the inevitable problems of translating laboratory results into publicly acceptable advice meant that research increasingly diverged from practice. There was also little scope for making legislative proclamations on disinfection standards or methods. The possibility of certainty offered by germ theory instead, perhaps paradoxically led in the short and medium term to a significant divergence between the different branches of disinfection, and resulted in more confusion and confrontation in the latter half of the century. Whilst disinfection was undoubtedly more widely discussed, more far ranging and more deeply embedded into local practice in the second half of the century than the first, this does not signify that its trajectory of implementation had followed a neat, linear line of ‘advance’. Investigating the day-to-day practices of local public health authorities in the context of wider changes in scientific knowledge highlights the limitations of new disease theories in exerting practical change, even where the theoretical ideas were accepted. It also shows that granting new powers using professional expertise and authority did not result in methodological improvements.

Disinfection and the public: the view of the public in public health

The role of the public in public health has been investigated in detail in a number of historiographical works. Historians have emphasised the variability of reactions, the various form of resistance of both the working class and the middle class property owners, based on their different preoccupations, and the limits put on policies by public opinion.¹⁶³¹ Disinfection reveals important aspects of the relationship between the public and public health policy and further illuminates the themes in the existing literature.

The need to accommodate public opinion emerges strongly in the history of disinfection, and was a significant limiting factor for policies. As disinfection was intrusive and potentially damaging, opposition might reasonably be expected and was thus a key concern. Both advice texts and practical policy makers acknowledged the need to take public views into account as a means of limiting resistance and of fostering co-operation. Damage to property was minimised, compensation usually offered for items damaged, and education campaigns aimed at highlighting the benefits of disinfection. The result was an increasing permeation of disinfection up the social hierarchy. This was in contrast to many public health policies which fell most heavily on the working classes. Municipal disinfection could be marketed as a service to benefit households, and

as a way to save householders' time and money. This promoted compliance and shows the extent to which scientific authority could overcome concerns about privacy. Public health, even its intrusion into the middle-class home, could be acceptable if the conditions were right.

Disinfection also reveals the gulf between public anxiety to undertake disinfection, and the significant professional mistrust of public ability to undertake effective health measures. Public interest in disinfection and germ theory grew rapidly from the 1870s onwards and was reflected in the increasing propensity of the public to engage in disinfection practices both in times of epidemic disease and more generally, integrating products like disinfectant soap into their usual cleansing routines. The public was increasingly convinced by germ theory and concerned about health, and what they could do to protect it. Whilst the ability to afford disinfectant preparations was mostly limited to the middle classes, by the end of the period the working class could engage in some forms of disinfection. In this they were directed by both professional and commercial interests, popular texts, advertising and the press. Given the diversity of the advice and individual preferences, it is unsurprising that public disinfection often did not correspond with professional advice. The increasing popularity of disinfection is nevertheless clear.

Private disinfection was increasingly dismissed as ineffective and problematic, with commentators condemning it and encouraging municipal authorities to take over disinfection. The public was seen as resorting to ineffective disinfectants for safety reasons and clinging to older methods because they were familiar, leading to a false sense of security, easier disease transmission and disillusionment with disease prevention. Additionally, where they managed to use more effective (but still fundamentally inadequate) preparations they were believed to mishandle or misuse them, leaving themselves vulnerable to harm and property damage whilst still not achieving "proper" disinfection". Commentators suggested a number of reasons for this, but agreed that public disinfection was, at best, suspect. The public, nevertheless, had to be involved in disinfection because of its exacting and specific nature. Many policies depended on the public undertaking disinfection within their homes for part of an illness. Successful disinfection involved the public in at least some of the processes, and local authorities took care to make sure this was feasible. Education, free disinfectants and other measures were employed to encourage better practice, and as much of the process as possible was removed from public fallibility. Various methods of disinfection were dangerous and could damage health, meaning that access to them needed to be managed. Legalisation increasingly curbed access to poisonous disinfectants. The approach demonstrates that, whilst public engagement was a necessary part of public health, the public was not to be completely trusted due to lack of specialist knowledge.

This reluctance had implications for disinfection practice, and reinforced the move towards professional authority in disinfection.

The various strands of disinfection history combine to reveal the complex and ambiguous underpinnings of public health. Germ theory overhauled concepts of disinfection, and influenced recommended practices. It also created a new structure by which disinfectants were tested, and a new faith in the ability to undertake reliable, “scientific” disinfection. This confidence in professional authority was paralleled by a lack of faith in public disinfection, based both on people’s presumed ignorance and tendency to be led astray by commercial interests and poor advice. The irony was that this proliferation of commercial interests and advice had itself resulted from germ theory. Attempts were made to counter this by education, information and coercion; but these were only a partial measure. The above advances underlined the necessity of entrusting disinfection to professionals, and the importance of professionals as the primary driver for disinfection advice. For this reason MOsH sought and were given, by national legislation, more power to direct and undertake disinfection, and the rights of the householder receded. The effectiveness of disinfection had been safeguarded. This did not, however, result in the improvements that might have been supposed. Whilst germ theory resulted in some changes in practice, practical factors meant that not all types of advice were changed by it. This linked to the problems of applying germ theory to disinfectant testing. Whilst theory changed the terms on which disinfectants were tested, researchers found it difficult to distinguish between promoting the search for scientific truth and attempting to guide practice and had not come to a satisfactory conclusion by 1914. This lack of clarity in research and practical obstacles affecting methods meant that the research agenda increasingly did not meet the needs of local MOsH, who favoured older practices. The new, germ-informed practice legitimised their power and characterized their professional authority but had limited impact. There was a tension at the heart of disinfection that illustrates an eternal problem in public health practice in reconciling the implications of scientific analysis with public opinion and the diversity of interests that are extant in any society.

Appendix One: Town Biographies.

All towns are in Lancashire. (The pre-1974 county)

Bolton

Bolton, located to the north-west of Manchester, became an important urban centre from the eighteenth century onwards.¹⁶³² The development of the cotton industry led to rapid population

growth; the population reached 50,163 in 1841, rising to 169,798 in 1901.¹⁶³³ The town became a substantial settlement with high population density.¹⁶³⁴ The occupational structure of Bolton was heavily dependent on cotton throughout the nineteenth century, although engineering, metalwork and coal mining were also important.¹⁶³⁵ The dependence on cotton was also reflected in high female employment rates.¹⁶³⁶ Bolton faced a range of typical urban health problems which made it unhealthier than the surrounding rural areas.¹⁶³⁷ Bolton provides an example of a typical medium sized urban industrial area.

Liverpool

The City of Liverpool is located on the Mersey estuary. The area had been settled since the middle ages, but experienced most growth in the nineteenth century. The city grew from 286,500 in 1841 to 746,000 in 1907.¹⁶³⁸ It was dominated by the port, and employment structures in the city were heavily influenced by the casual and temporary work the port demanded.¹⁶³⁹ The city faced numerous health challenges due to its poor housing and role as a port, which resulted in a wide range of exotic diseases being imported into the city.¹⁶⁴⁰ Liverpool was the first city in the country to appoint a MOH in 1848, and started its - public health programme early in the century.¹⁶⁴¹ Liverpool provides an interesting example of a large city facing a particularly demanding range of health problems.

Manchester

Manchester is located in the south of Lancashire. The settlement dates back to the medieval period, and, with many of the other case studies, grew greatly in size in the nineteenth century.¹⁶⁴² Politically, the city council was dominated by large proprietors, giving way to merchants, shopkeepers and agents as the century progressed.¹⁶⁴³ There was also a split between Liberal and Tory elites in the city.¹⁶⁴⁴ The city is most associated with the cotton industry, but saw some diversification of its industrial base in the late nineteenth century and had high levels of female employment.¹⁶⁴⁵ Manchester had a reputation for poor living conditions, but was not especially unhealthy and faced no exceptional problems.¹⁶⁴⁶ The city started a health programme from the

1840s onwards, which expanded as the century progressed.¹⁶⁴⁷ As another large city, Manchester provides an interesting counterpoint to Liverpool.

Preston

Preston is located on the River Ribble, in the centre of the county of Lancashire. Settled since the medieval period, by the eighteenth century Preston was a small market town.¹⁶⁴⁸ It grew dramatically during the Industrial Revolution (the model for Dickens' 'Coketown'), with the population increasing from 50,131 in 1841 to 117,088 in 1911.¹⁶⁴⁹ The town was dominated by the cotton industry throughout the nineteenth century.¹⁶⁵⁰ There were high levels of female employment in Preston, and low male wages.¹⁶⁵¹ Preston was not extensively suburbanised in 1881, with continued mixing of all social groups, although there was some trend towards suburbanisation by 1900.¹⁶⁵² Preston was notorious for its high death rates, including infant mortality, which reached a peak in the 1890s.¹⁶⁵³ It was also thought to have a poor attitude to public health policy, undertaking only the bare minimum necessary to comply with the law.¹⁶⁵⁴ Preston provides an interesting example of a town with a poor public health record.

St. Helens

St. Helens is located in the south west of Lancashire, between Liverpool and Wigan. The town was a new settlement, developed in the nineteenth century, and was incorporated in 1868.¹⁶⁵⁵ The population was 11,000 in 1845, rising to 96,551 in 1911.¹⁶⁵⁶ St. Helens was dominated by the coal mining, glassmaking and chemical industries. The town had very low levels of female employment.¹⁶⁵⁷ Local government was somewhat haphazard at first, with several local boards having authority over aspects of public services and management.¹⁶⁵⁸ The town was nevertheless determined to take action to safeguard the health of its population whilst it was still growing, and despite some slum areas and significant environmental pollution, St. Helens was not as insanitary as some of the larger towns.¹⁶⁵⁹ The town had a comparatively poor record for public health policy.¹⁶⁶⁰ St. Helens is an interesting example of a new town.

Bibliography

Local Archive Sources

Bolton Archive, Bolton

Bolton Medical Officer of Health Reports, 1874-1914.

Bolton Sanitary Committee Minute Books, AB16.1.1.(2-20), 1863-1914.

Documents on the Notification of Tuberculosis, 1905.

Dr. Ballards Report on the Sanitary Condition of Bolton, 1872, Bolton Archive, Bolton.

House of Commons Select Committee Evidence relating to Bolton Improvement Act, 1877,
Bolton Archive, Bolton.

Harris Library, Preston

Preston Medical Officer of Health Report, 1901.

Lancashire County Record Office, Preston

Preston Printed Council Proceedings, 1877-1914, Lancashire County Record Office, Preston.

Lancashire County Council Medical Officer of Health Reports, 1889-1914, Lancashire County
Record Office, Preston.

Liverpool Archive

Accounts, 1867-8.

Estimates and Expenditure Report, 1914.

Handbook For the Congress of the Royal Institute of Public Health, 1903.

Income and Expenditure Under the Sanitary Act, 1856.

Medical Officer of Health Letter on Disinfection, 1874.

Medical Officer of Health Circulars Book, Tuberculosis Report 1897.

Printed Council Proceedings, Medical Officer of Health Reports, 1862-1914.

Reports and Comparative Statements Under the Finance Act, 1915

St. Helens Archive, St. Helens

Letters and Documents Relating to the Disinfectors, 1893, ST/1/111/1-5.

Liverpool Return, St. Helens Sanitary Survey, 1890, ST.1.196.2.

Local Government Board Memorandum on Infectious Disease, 1888) ST.8.1.1-29.

St. Helens Archive, St. Helens Medical Office of Health Reports, 1874-1914.

St. Helens Town Council Printed Proceedings, 1890-1914.

St. Helens Health Committee Minute Book, 1907-9, St. Helens Archive, St. Helens, 58.

Sheffield Archive, Sheffield

Izal Company Papers, TR443, Sheffield Archive, Sheffield.

Izal Promotional Materials, TR444, Sheffield Archive, Sheffield.

Wellcome Trust Library, London

Manchester Medical Officer of Health Reports, 1868-1914.

Manchester Infectious Disease Report, 1871.

Disinfection Ephemera, EPH 175.2-3.

Disinfection Ephemera, EPH 175.3-23.

Journals and Newspapers

Bolton Journal

Bolton Chronicle

The Bolton Evening News

The British Journal of Tuberculosis

The British Medical Journal

Chemist and Druggist

Journal of Hygiene

Journal of Preventative Medicine

Journal of the Royal Institute of Public Health

Journal of State Medicine

Journal of The Sanitary Institute

Journal of The Society of Chemical Industry

The Lancet

Liverpool Review

Liverpool Mercury

Manchester Times

The Medical Times and Gazette

The Practitioner

The Preston Guardian.

Public Health

The Porcupine

The Sanitary Inspectors Journal

The Sanitary Journal

The Sanitary Journal, A Journal of Hygiene and Public Health (Footnoted as Scottish Sanitary Journal).

St. Helens Newspaper and Advertiser

Students Journal and Hospital Gazette

The Times

Transactions of The Sanitary Institute of Great Britain

Legislation and parliamentary papers

A Bill for Establishing Regulations for the Sale of Poisonous Drugs, (1819), I-B, 943.

An Act to amend the law relating to Public Health, 29th and 30th Vict. Cap 90 (1866).

An Act to consolidate and amend the Nuisances Removal and Diseases Prevention Acts, 1848 and 1849, 18th and 19th Vict. Cap. 121, (1855).

An Act to Regulate the Sale of Poisons, 31st & 32nd Vict. C. 121, (1868).

An Act to Regulate the Sale of Poisons, 8th Edw. 7, Ch. 55, (1908).

Bolton Improvement Act, 1877, 40 & 41 Vict. Ch. CXXXVIII.

Bolton Corporation Act 1882, 45 & 46 Vict. Ch. CCXLIV.

Bolton Corporation Act, 1905, 5th Edw. 7th, C. CCIV

Chloride of Zinc: Copies of Reports to the Naval Department Since Last July, (1847-8) LI, 407.

Cleansing of Persons Act, 60 and 61st Vict., Ch. 31., (1897).

Committee on Poisons. Report, Supplementary Report and Minority Report, Part I. (1903), XXXIII,

1.

Common Lodging Houses Act, 1851, 14th and 15th Vict. C. 28.

Common Lodging Houses Act, 1853, 16th and 17th Vict. C. 41

Disinfecting Fluid. Copy of Reports on the Efficacy of Monsieur Ledoyen's Disinfecting Fluid, (1847), LVII, 9/57.

Fifteenth Annual Report of the Local Government Board, 1885-86: Supplement Containing the Report of the Medical Officer for 1885, (1886), XXXI, 467.

Fourteenth Annual Report of the Local Government Board 1884-85: Supplement containing the report of the Medical Officer for 1884, (1884-85), XXXIII, 227

Infectious Disease (Prevention) Act, 53rd and 54th Vict. Ch. 34, (1890).

Metropolitan Sanitary Commission: Second Report of the Commissioners Appointed to Inquire Whether Any and What Special Means May be Requisite for the Improvement of the Health of the Metropolis, (1847-8), XXXII, 253/293.

Manchester Waterworks and Improvement Act, 1872, 35th and 36th Vict., C. XXXI.

Minutes of Evidence Taken Before the Departmental Committee to Consider Schedule A. to the Pharmacy Act, 1868, Part II, (1903), XXXIII, 17.

Infectious Disease Notification: Copy of Several Communications Received by the Local Government Board, (1882), LVII, 587.

Preston Improvement Act, 1880, 43rd and 44th Vict., C. CXVIII.

Public Health Act, 38 and 39th Vict. Cap 55, (1875).

Public Health Amendment Act, 7th Edw. C. 73, (1907).

Report From the Committee on Dr. Smyth's Petition Respecting his Discovery of Nitrous Fumigation, (1802), II, 381, 389.

Report from the Select Committee of the House of Lords on the Sale of Poisons, (1857), XII, 551.

Reports of the Medical Officer of the Privy Council and Local Government Board: Report to the Lords of the Council on Scientific Investigations, (1875), XL, 393.

St. Helens Corporation Act, 1893, 56th and 57th Vict., C. CCXV.

St. Helens Corporation Act, 1911, 1st and 2nd Geo., C. CCXVII.

Tenth Annual Report of the Local Government Board, 1880-1, 1882, 43rd and 44th Vict., XXX, 1-234.

Primary published texts

Acland, J. B., *Notes on Sheep-Farming in New Zealand*, (London, 1858).

Adams, J., 'On disinfection by heat', *Transactions of the Sanitary Institute*, 5, (1883-4): 303-24.

Aiken, C. M., *Air, Water and Disinfectants*, (London: SPCK, 1895).

Ainslie Walker, J. T., 'The use of disinfectants from an ethical point of view', *The Lancet*, (Feb 24th 1906): 549.

Alcock, T., *An Essay on The Use Of Chlorurets of Oxide of Sodium and Of Lime*, (London: Burgess and Hill, 1827).

Aldwinckle, T. W., "Disinfecting Apparatus", *Public Health*, (1897-8): 93-7.

Alexander, F. W., "Facts about carbolic", *The Lancet*, (Jan 20th 1900): 158-9.

Alexander, F. W., 'Standardisation of disinfectants: perplexity', *The Lancet*, (14th Jul 1906): 123.

Allan, F. J., "Proceedings of the metropolitan branch", *Public Health*, 9, (1896-7): 183-7.

Allan, F. J. "Supplement" in M. Rosenau, *A Practical Guide to Disinfection*, (London, Robman, 1903).

Allbutt, H A., *Every Mother's Handbook*, (London: London: Simpkin, Marshall, Hamilton, Kent & Co, 1897).

Allbutt, H. A., *The Wife's Handbook*, 2nd ed. (London: W. J. Ramsey, 1886).

- Allbutt, H. A., *Wife's Handbook*, (London: R. Forder, 1891).
- Andrewes, F. W., *Lessons in Disinfection and Sterilisation*, (London: Churchill, 1903).
- Andrewes, F. W., *Lessons in Disinfection and Sterilisation*, 2nd Ed., (London: Churchill, 1907).
- Anderson, A. J. "The notification of measles", *Public Health*, 5, (1892-3): 207-10.
- Anonymous, *The Practical Housewife*, (London: Houlston and Wright, 1860).
- Anonymous, *The Disinfectant Question*, (London: Sanitary Record, Corquodale and Co., 1869).
- Anonymous, *Pharmacy and Poisons Act*, (London: Chemist and Druggist, 1893?).
- Anonymous, *Sanitary Record Yearbook and Diary*, (London: Sanitary Record, 1908).
- Anonymous, *Sanitary Record Diary*, (London: The Sanitary Record, 1901).
- Anonymous, *Mothers Medical Adviser*, (London: Ward and Lock, 1860).
- Anonymous, *Reports, Certificates, Letters and Opinions on Mr. Ledoyen's Disinfecting Fluid*, (NY: Oliver and Brothers, 1848), 8-9.
- Arms, B. L. and C. F. Whitney, "The treatment of rooms after diphtheria and scarlet fever", *American Journal of Public Health*, 10, (October 1912): 799-801.
- A Subscriber, "Cholera and the question of its contagion", *The Lancet*, (1st July 1848): 14.
- Averill, C., *Facts Regarding the Disinfecting Powers of Chlorine*, (Schenectady, S. Riggs, 1832).
- Ayres, B., "On the nature and result of the putrefactive fermentation of animal and vegetable matters", *The Lancet*, (22nd April 1848): 445-7.
- Babington, B. G., 'Reports of societies', *British Medical Journal*, (April 6th 1861): 373-4.
- Babington, B. G. 'Reports of societies', *British Medical Journal*, (April 7th 1860): 272-5.
- Bastick, W., "Reports on the progress of chemistry", *The Lancet*, (8th November 1856): 520-22.
- Baxter, Dr., "Disinfection", *Medical Times and Gazette*, (May 12th 1877): 513-514.
- Beale, L., *Disease Germs: Their Real Nature*, (London: J. Churchill, 1870).
- Beale, L., *On Personal and Domestic Hygiene*, (London: J&A Churchill, 1885).
- Beckurts, H., "Quantitative determination of phenol", *Journal of the Society Chemical Industry*, (Oct 29th 1886): 547.
- Bedford Kostoven, W., *A Manual of the Domestic Practice of Medicine*, (London: Longman, Brown, Green and Longmans, 1856).
- Beeton, I., *Book of Household Management*, (London: Ward, Lock and Co., 1888).
- Beeton, I., *Book of Household Management*, (London: Ward, Lock and Co., 1883).
- Beeton, I., *Book of Household Management*, first published 1851, (Ware: Wordsworth Editions,

2006).

Beveridge, W. and C. F. Wanhill, *The Sanitary Officers Handbook*, (London: Edward Arnold, 1912).

Bickerton, T. H., *A Medical History of Liverpool*, (London: John Murray, 1936).

Bostock Hill, A., "Sanitary jottings", 1, *Public Health*, (1888-9): 25-9.

Bond, F. T. "On the conditions of efficient disinfection", *British Medical Journal*, (Feb 20th 1875): 239-41.

Bright, J., "Preparation of Chlorine in Scarlet Fever", *The Lancet*, (9th March 1833): 748-9.

Brown, R. K., "Disinfection after measles", *Public Health*, 19, (1906-7): 239-43.

Brown, R. K. "Disinfection after measles", *Public Health*, 20, (1907-8): 257-9.

Budd, W., *Typhoid fever: its Nature, Mode of Spreading, and Prevention*, (London: Longmans, Green, 1873).

Budd, W., *Scarlet Fever and its Prevention*, (London: Sampson Low, Son, and Marston, 1869).

Budd, W., *Malignant Cholera*, (London: John Churchill, 1849).

Budd, W., "On the contagion of yellow fever", *The Lancet*, (6th April 1861): 337-8.

Burnett, W., *Reports and Testimonials Respecting Chloride of Zinc*, W. Burnett, (S. Mills, London, 1850).

Burn Russell, J., *Public Health Administration in Glasgow*, (Glasgow, J. Maclehose, 1905).

Calvert and Co., "Letter", *Medical Times and Gazette*, 60, (1880): 83.

Cameron, C. A., *The Prevention of Contagious Diseases*, (London: Balliere, Tindall and Co., 1871).

Cameron, C. A., *The Prevention of Contagious Diseases*, 2nd ed., (London: Balliere, Tindall and Cox, 1874).

Cameron, C. A., *A Manual of Hygiene*, (London: Balliere, Tindall and Co., 1874).

Chalmers, A. K., "The control of infectious disease", *Scottish Sanitary Journal*, 1, (1894-5): 440-9.

Chapin, C., *The Sources and Modes of Infection*, (London: John Wiley, Chapman & Hall, 1910).

Cheyne, W. W. (ed.), *Recent Essays by Various Authors on Bacteria in Relation to Disease*, (London, New Sydeham Society, 1886).

Chick, H., 'An investigation into the laws of disinfection', *Journal of Hygiene*, (January 1908): 92-158.

Chick, H., and C. J. Martin, 'The principles involved in the standardisation of disinfection', *Journal of Hygiene*, 8, (Nov 1908), 654-97.

Church, H. J., *Carbolic Acid as a Disinfectant and as a Means of Preventing the Spread of Cattle Plague*, (London: R. Hardwicke, 1866).

City of Liverpool, *City Hospital Fazackerley Pamphlet*, (Liverpool: Lee and Nightingale, 1906).

Coates, W., "Poisoning by mercuric chloride", *The Lancet*, (16th Sept. 1899): 784-785.

Cobbett, L. and J. H. C. Dalton, "Some experiments on the sterilising properties of unconfined superheated steam", *The Lancet*, (3 Feb 1900): 299-303.

Collins, Sir W., "Man v. Microbe", *Sanitary Journal*, (1902-3): 126-35.

Condy, H. B., *Disinfection and the Prevention of Disease*, (London: John W. Davies, 1862).

Congress Committee, *Jubilee Retrospect of the Royal Sanitary Institute, 1876-1926*, (London: Royal Sanitary Institute, 1926).

Copland, J., *A Dictionary of Practical Medicine*, (London: Longman, Brown, Green and Roberts, 1858).

Coote Hibbert, J. "The aid of bacteriology in sanitary administration", *Public Health*, 22, (1908-9): 264-8.

Coote Hibbert, J., "Disinfectants and their uses", *Public Health*, 22, (1908-9): 465-6.

Conn, H. W. *Story of Germ Life*, (London: George Newnes, 1897).

Crisp, E., *Smallpox and its Prevention*, (London: Robert Hardwicke, 1871).

Crookshank, E., *Manual of Bacteriology*, (London: H.K. Lewis, 1887).

Curwen, Miss M., "Household bacteriology", *Journal of the Sanitary Institute*, (1903): 762-4.

Curwengen, J. B., *The Disinfection of Scarlet Fever*, (London: H. K. Lewis, 1891).

Davies, A. M., *A Handbook of Hygiene*, (London: C. Griffin and Company, 1895).

Davies, A. M., *A Handbook of Hygiene*, 2nd Ed., (London: C. Griffin and Company, 1901).

Davies, A. M., *A Handbook of Hygiene*, 4th Ed., (London: C. Griffin and Company, 1913).

Davies, J. H., "[Two](#) cases of fatal poisoning by carbolic acid", *The Lancet*, (8th March 1890), 539.

Davies, J. H., "[Preventable Poisoning](#)", *The British Medical Journal*, (Feb. 23rd 1889): 424-425.

Davies, A., "Disinfection", *The Practitioner*, 32, (1884): 67-80.

Davies, D.S., "Diphtheria and smallpox", *Public Health*, (October 1906-September 1907): 349-370.

Davis, O., "Disinfectants and antiseptics", *Journal of the Sanitary Institute*, 14, (1906): 563-7.

De Salis, Mrs, *Housewives Reference*, (London: Hutchinsons and Co., 1899).

Defries, W., "Disinfection methods", *Journal of State Medicine*, 4, (1896): 10-22.

Defries, W., "Heat Disinfection", *Journal of the Sanitary Institute*, (1894): 528-32.

Defries, W., "Formic aldehyde and the examination of disinfectants", *Public Health*, 10, (1897-8): 214-5.

Defries, W., "Formaldehyde disinfection", *Public Health*, 10, (1897-8): 135.

Defries, W., "Disinfection by low-pressure steam", *Public Health*, 10, (1897-8): 246-49.

Defries, W., "The essential conditions of steam disinfection", *The Lancet*, (21st Oct 1905): 1213-5.

Defries, W., "The essential conditions of steam disinfection", *The Lancet*, (30th Sept 1905): 984-8.

Defries, W., "Disinfection", *The Practitioner*, 75, (1905): 431.

Defries, W., "Disinfection methods", *Journal of State Medicine*, 4, (1896): 10-22.

Defries, W., 'Examination of disinfectants', *Journal of the Sanitary Institute*, (1897): 418-20.

Defries, W., "The disinfection of rooms", *Public Health*, 7, (1894-5): 335-337.

Defries, W., "The essential conditions of steam disinfection", *The Lancet*, (30th Sept 1905): 984-8.

Delepine, S., *The Essentials of Disinfection and Sterilization by Steam*, (London: Thresh Disinfecting Company, 1909).

Delepine, S., "The standardisation of disinfectants", *Journal of The Royal Institute of Public Health*, 16, (1908): 577-95.

Delepine, S., and A. Ransome, 'On the disinfection of tuberculously infected houses', *British Medical Journal*, (Nov 4th 1893): 990-2.

Delepine, S., and A. Ransome, 'A report on the disinfection of tubercle infected rooms', *British Medical Journal*, (Feb. 16th 1895): 349-55.

Dewar, J., *On the Application of Sulphurous Gas*, (Edinburgh: 1866).

Dougall, J., *On the Relative Powers of Various Substances in Preventing the Generation of Animalculae*, (London: J&A Churchill, 1871).

Dowling, J., *Handbook of Health and Hygiene*, (Dublin : M.H. Gill and Son, 1897), 64.

Dutton, T., *Domestic Hygiene*, T. Dutton, (London : Henry Kimpton, 1894).

Dixon Savill, T., *Prescriber's Companion*, (London: John Bale, Sons & Danielsson, Ltd., 1900).

Drysdale, J., *Germ Theories of Infectious Diseases*, (London: Bailliere, Tindall & Cox, 1878), 22.

Dyer, Dr., "Yorkshire Meeting", *Sanitary Journal*, 8, (1902-3): 208-211.

Eade, Dr., "Case of poisoning by corrosive sublimate", *The Lancet* (26th February 1870): 302-303.

Ellerman, C.F., *Disinfection*, (London: Geo. Peirce, 1847).

Ellis, E., *What Every Mother Should Know*, (London: J. & A. Churchill, 1881).

Elliston, W. A., 'The value of disinfectants', *British Medical Journal*, (30th Oct 1886): 809-10.

Entwistle, J., *A Report on the Sanitary Condition of the Borough of Bolton*, (Bolton: H. Bradbury, 1848).

Evans, M., *The Sanitary Annual and Record of Sanitary Science*, (London: Williams and Norgate, 1889).

Feldman, W. M., *A Manual of Nursery Hygiene*, , 2nd ed. (London: Balliere, Tindall and Cox, 1912).

Fergus, J. F., "History and treatment of cholera", *The Lancet*, (23rd June 1832): 353-61.

[Ferrier](#), D., "[Poisoning By Carbolic Acid](#)", *The British Medical Journal*, (Feb. 15th 1873): 167-168.

Fleming Phillips, W., *The Proper Use of Disinfectants*, (London: Simpkin, Marshall and Co., 1879).

Freeman, A., *The Planning of Fever hospitals and Disinfecting and Cleansing Stations*, (London: The Sanitary Publishing Company, 1909).

Flugge, C., *Micro-Organisms, With Special Reference to the Etiology of the Infective Diseases*, tr. W. Watson, Cheyne, (London: New Sydenham Society, 1890).

Ford, F. Caiger, "Cubicle isolation", *Public Health*, October 1910-September 1911: 336-348.

Fowler, C. E. P., *The Bacteriological Examination of Disinfectants*, (London: The Sanitary Publishing Co., 1907).

Frankel, C., 'The disinfecting properties of creosote', *Journal of the Society of Chemical Industry*, (Nov. 30th 1889): 912.

Franklin Parsons, H., P. Caldwell Smith, W. Squire, E. W. Hope, C. H. Allfrey, 'A discussion on disinfection and isolation', *British Medical Journal*, (Aug 31st 1889): 452-9.

Fox, W. T., *Cholera Prospects*, (London: 1865).

Galsworthy, J., *The Forsyte Saga Volume Two*, (London: Penguin, 1967).

Gay, J., *Disinfection and Disinfectants*, (London: The National Health Society, 1895).

Giffen, G. H., *Students' Manual of Medical Jurisprudence and Public Health*, (Edinburgh: William Bryce, 1901).

Giffen, G. H., *Students' Manual of Medical Jurisprudence and Public Health*, 2nd Ed., (Edinburgh: William Bryce, 1906).

Gordon Pugh, W. T., "An address on scarlet fever", *The Lancet*, (4th February 1905): 273-278.

Green, R., "Experiments on disinfection", *Public Health*, 16, (1903-4): 558-62.

Greenwood, A., "Aetiology of infectious influenza", *The Practitioner*, 48, (1892): 401-16.

Grove, J., *Epidemics Examined and Explained*, (London: J. Ridgway, 1850).

Hall, O., "Relative value of disinfectants", *Journal of the Sanitary Institute*, (1910): 164-71.

Hamer, W., *Manual of Hygiene*, (London: J. & A. Churchill, 1902).

Hamer, H., *The Book of Bolton*, (Bolton: Tillotsons, 1929).

Hancock, J., "Remarks on the disinfecting power of heat", *The Lancet*, (18th Aug 1832): 620-4.

Harrington, C., *Manual of Practical Hygiene*, C. Harrington, (London, 1901).

Harris, A. E., "The fatal record of carbolic acid", *The Lancet*, (28th November 1896): 1519-1520.

Harris, Dr., "Efficiency of disinfection processes", *Public Health*, 11, (1898-9): 244.

Harris, C. and C. Prausnitz, "The determination of the efficiency of disinfection", *Journal of the Royal Institute of Public Health*, 15, (1907): 147-151.

Harrison, G. W., "[Case](#) of suicide by carbolic acid", *The Lancet*, (25th July 1868): 133.

Harley Williams, J. R., *A Century of Public Health in Britain*, (London: A. & C. Black, 1932).

Hart, F., *Manual of Public Health*, (London: Smith, Elder and Co., 1874).

Hart, E., "Parliamentary Bills Committee", *British Medical Journal*, (Feb. 14th 1880), 259-62.

Hartley, N., *Air, Water and Disinfectants*, (London: SPCK, 1877).

Hassall, R., "Clinical Contributions", *The Lancet*, (20th August 1853): 159-160.

Hatfield Walker, T., 'Disinfectants', *The Lancet*, (Aug. 9th 1884): 258.

Henry, W., "Analytic Notice", *The Lancet*, (21st Jan 1832): 600-4.

Henry, W., "Disinfection by heat: letter from Dr. Henry", *The Lancet*, (21st April 1832): 92-3.

Henry, M., "Practical clinical remarks on wounds", *The Lancet*, (10th Dec. 1859): 579-81.

Herbert Barker, T., "The Hastings Prize Essay, 1865", *British Medical Journal*, (January 6th 1866): 1-16.

Highet, J., "[The need of a state department of public health](#)", *Public Health*, (1900): 851-858.

Hogarth, A. M., "The value of disinfection", *Public Health*, 1909-1910: 333.

Homersham, E. M., *Home Nursing*, (London: National Health Society, 1888).

Houston, A., "Practical disinfection of schools", *The Practitioner*, 69, (1902): 300;

Ingleby, J. T., "Clinical lectures on midwifery", *The Lancet*, (8th Feb. 1840): 633-9.

Jalland, W. H., "Reports of Hospital and Surgical Practice in the Hospitals and Asylums of Great Britain, Ireland, and the Colonies", *British Medical Journal*, (June 25th 1887): 1387 – 1388.

Joll, B., *Nursery Hygiene*, (London: Kimpton, 1884).

Jones, T. H., "The disinfection of schools", *Public Health*, 22, (1908-9): 463-4.

Hutchins, J. B., *Cholera Orders, Directions and Regulations of the Privy Council*, (London: Shaw and Sons, 1866).

Kanthack, A. A., "The use of formalin lamps", *The Lancet*, (Oct 22nd 1898): 1049-51.

Kenwood, H. R. and P. J. Wilkinson, "Disinfecting stations", *Journal of the Sanitary Institute*, (1904): 138.

Kenwood, H., "The control of disinfectants", *The Lancet*, (7th Nov 1908): 1400.

Kenwood, H., "Some observations upon the subject of disinfection", *Public Health*, 18, (1905-6): 265-8.

Kenwood, H., "Some observations on disinfection", *Public Health*, 21, (1908): 4-14. .

Kenwood, H. and R. T. Hewett, "The practical standardisation of disinfectants", *Public Health*, 18, (1905-6): 462-7.

Kenwood, H., "The unbridled practice of medical quackery", *Public Health*, 13, (1900-1): 99-106.

Kenwood, H. and A. Zimmerman, "Formaldehyde disinfection", *Public Health*, 10, (1897-8), 175-6.

Kenwood, H., "Formaldehyde disinfection", *Public Health*, 10, (1897-8): 104.

Killick Millard, C., "[The Leicester method of dealing with smallpox](#)", *Public Health*, 16, (October 1903-September 1904): 617.

Killick Millard, C., "The influence of hospital isolation on scarlet fever", *Public Health*, 13, (1900-1901): 462-70.

Kingzett, C. T., "On the comparative antiseptic value of substances", *Journal of the Society of*

- Chemical Industry*, (Nov 30th 1888): 716.
- Kingzett, C. T., "Disinfection and disinfectants", *The Sanitary Inspectors Journal*, 7, (1900-1): 220.
- Kingzett, C. T., "The comparative value of antiseptics", *Students' Journal and Hospital Gazette*, 16, (1888): 670.
- Kingzett, C. T., A. Wynter Blyth, 'The standardisation of disinfectants', *The Lancet*, (26th Dec 1908): 1941-2.
- Kingzett, C. T., "On the precise relations of micro-organisms to disease", *British Medical Journal*, May 16th 1885: 960-1.
- Kingzett, C. T., "The standardisation of disinfectants", *The Lancet*, (Dec. 18th 1909): 1849-52.
- Kingzett, C. T., 'Standardisation of disinfectants', *Sanitary Journal*, 15, (1909-10): 211.
- Kingzett, C. T., "The Lancet Report: Letter", *Journal of State Medicine*, 16, (1910): 122.
- Kingzett, C. T., *A Precise Investigation of Some Micro-Organisms and Soluble Ferments*, (London: [s.n.], 1887).
- Kingzett, C. T., 'Letter from Mr. Kingzett' *Chemist and Druggist*, (Dec 20th 1909): 978.
- Kingzett, C. T., "Correspondence", *Public Health*, 21, (1908): 83.
- Klein, E., *Micro-organisms and Disease*, (London: Macmillan, 1886).
- Klein, E., "On the disinfectant action of sodium hypochlorite", *The Lancet*, (Nov. 28th 1896): 1509-10.
- Klein, E., 'Observations on the value of some of the methods used for testing disinfectants', *British Medical Journal*, July 1904, 13-15.
- Klein, E., "An improved coal tar disinfectant", *The Lancet*, (21st March 1903): 829.
- Koch, R., "On disinfectants", *Journal of the Society of Chemical Industry*, (Oct 19th 1882): 423.
- Koch, R., "The combating of tuberculosis", *Public Health*, 13, (1900-1): 464-77.
- Koch, R., 'An address on bacteriological research', *British Medical Journal*, (16th Aug 1890): 380-3.
- Koch, R., and Dr. Wolfhugel, "Essay on disinfection", in W. Watson Cheyne, (ed.), *Recent Essays by Various Authors on Bacteria in Relation to Disease*, (London: New Sydeham Society, 1886).
- Koch, R., R. Pettenkofer and Dr. Wolfhugel, "The value of sulphurous acid as a disinfectant",

- Medical Times and Gazette*, 64, (April 29th 1882): 449-50.
- K.T.L, National Health Society Medallist, *Notes on Domestic and Personal Hygiene*, (London: Allman & Son, Ltd., 1890).
- Labarraque, A., *The Use of the Chlorate of Soda*, (London: S. Highley, 1826).
- Lane Notter, J. L. and R. H. Firth, *The Theory and Practice of Hygiene*, (London: J. & A. Churchill, 1896).
- Lane Notter, J. L. and R. H. Firth, *The Theory and Practice of Hygiene*, 4th Ed., (London: J. & A. Churchill, 1900).
- Lane Notter, J. L. and R. H. Firth, *Practical Domestic Hygiene*, (London: Longman and Green, 1897).
- Lane Notter, J. L. and R. H. Firth, *Theory and Practice of Hygiene*, 7th Ed., (London: J&A Churchill, 1908).
- Lane Notter, J. L., *The Chemical Theory of Contagion*, (London: Balliere, Tindall and Cox, 1877).
- Lane Notter, J. L. and R. H. Firth, *Extracts From a Chapter on Disinfection*, (Thorncliffe: Newton, Chamber and Co., 1900).
- Lawrence, Mr., "Lecture on surgery, medical and operative", *The Lancet*, (26th Dec 1829): 425-32.
- Leslie Mackenzie, W., "Methods of disinfection", *Public Health*, 12, (1900): 438-48.
- Leslie Mackenzie, W., "Disinfection by spray", *Sanitary Journal*, 4, (1897-8): 4-13.
- Lloyd, T. H., "Manufacture and supply of electrolytic disinfectant by the public health authority", *The Lancet*, (16th June 1906): 1715-16.
- Loane, M. *From Their Point of View*, (London: Edward Arnold, 1908).
- McLagen, T., *The Germ Theory of Disease*, (London: Macmillan and Co., 1876).
- McLean Wilson, H., "[Treatment](#) of trade effluents: tanyard sewage", *Public Health*, (1891-1892): 334-335.
- McNally, C. J., *The Elements of Sanitary Science*, (London: H. K. Lewis, 1889).
- McDougall Bros., 'Standardisation of disinfectants', *The Lancet*, (5th Dec 1908): 1709.

- Mackenzie, Dr. L., "Methods of disinfection", *Public Health*, 12, (1900): 438-448.
- Mackenzie, W. Leslie, "A simple and portable spray pump for disinfection", *British Medical Journal*, (Sep. 28th 1901): 898-900.
- MacMichael, W., *A New View on the Infection of Scarlet Fever*, (London: T. & G. Underwood, 1822).
- Marchant, F., "A note on the carbolic co-efficient of disinfectants", *The Lancet*, (Nov 4th 1911): 1267.
- Magnin, A., *Bacteria*, tr. Dr. Sternberg, (New York: W. Wood and Company, 1884).
- Mearns Fraser, A., "A new method of disinfection by current steam", *Journal of State Medicine*, 4, (1896): 22-30.
- Medical Officer of the Schools Association, *A Code of Rules for the Prevention of Infectious and Contagious Diseases*, (London: J.&A. Churchill, 1902).
- Meredith Richards, H., "The cleansing of schoolrooms", *Public Health*, 22, (1908-9): 461-2.
- Meredith Richards, H., "The co-ordination of medical inspection with public health work", *Public Health*, 1908-9: 166-9.
- Meredith Richards, H., "Some thoughts on disinfection", *Public Health*, 23, (1909-10): 42-4.
- Messiter, A. F., "Remarks and suggestions with regard to the disinfection of clothes by heat", *The Lancet*, 150, (20th Nov 1897): 1305-6.
- Middleton Hewatt, A., "The disinfection of tubercule infected houses", *British Journal of Tuberculosis*, 8, (1914): 147-151.
- Miller, J. W., "A contribution to the study of disinfection", *The Practitioner*, 33, (1884): 185-97.
- Moor, C. G. and R. Tanner, *Applied Bacteriology*, (London: Bailliere, Tindall and Cox, 1906).
- Moor, C. G., "Disinfection", *Journal of Preventative Medicine*, 13, (1905): 206-16.
- Moor, C. G., "Problems in practical disinfection", *Journal of Preventative Medicine*, 13, (1905): 206-16.
- Moore, Dr. S. G, comment in "Standardisation of disinfectants: discussion", S. Rideal and J. Walker, *Journal of the Sanitary Institute*, (1903): 440.
- Mouat, F. J., "On hospitals", *The Lancet*, (June 18th 1881): 979-82.
- Muir, R., *A History of Liverpool*, (Liverpool: Liverpool University Press, 1907).
- Murray, J., *A Treatise on Pulmonary Consumption*, (London: Whittaker, Treacher and Arnott, 1830).
- Murell, W., "The Local Government Board disinfectant solution", *British Medical Journal*, (June 10th 1893): 1241-2.

Mundie's Disinfectant Company, *What to Do in Disinfection And How To Do It*, (London: E. W. Allen, 1872).

Muter, J., "[Poisoning By Carbolic Acid](#)", *The British Medical Journal*, (May 28th 1870): 561.

National Health Society, *How to Prevent and Oppose the Cholera*, (London: National Health Society, 1884).

National Health Society, *In a Sick Room*, (London: National Health Society, 1884).

National Health Society, *Hints to Avoid Fevers*, (London: Allman and Sons, c.1884).

Nash, J. T. C. , "Disinfection and disinfectants", *The Practitioner*, 79, (1907): 412-419.

Nasmyth, T. G., *Manual of Public Health*, (Edinburgh: T&T Clark, 1890).

Nasmyth, T. G., "Formaldehyde disinfection", *Scottish Sanitary Journal*, (Glasgow, 1899-1900): 497-508.

Naylor Barlow, T. W., "Disinfectants: their scientific uses, their quack uses and their dangers", *Public Health*, 23, (1909-10): 230-9.

Neech, J. T., 'Standardisation of disinfectants', *Public Health*, 18, (1905-6): 523.

Newton Drew, W., 'The standardisation of disinfectants', *The Lancet*, (12th December 1908): 1772.

Newsholme, A., *Fifty Years in Public Health*, (London: G. Allen & Unwin Ltd., 1935).

Newsholme, A., "[An address on the prevention of phthisis](#)", *The Lancet*, 153, (4th February 1899): 279-282.

Newsholme, A. "Tuberculosis in England", *Journal of Hygiene*, 4, (1903): 446-67.

Newsholme, A., "Public health authorities in relation to the struggle against tuberculosis in England", *Journal of Hygiene*, 3, (1903): 446-67.

Newsholme, A., "The utility of isolation hospitals in diminishing the spread of scarlet fever", *Journal of Hygiene*, 1, (1901): 145-52.

Newman, G., *Bacteria*, (London: John Murray, 1899).

Newman, G., *Bacteriology and the Public Health*, G. Newman, (London: Murray, 1904).

Noble Twelvetrees, W., "Disinfection", *The Sanitary Inspectors Journal*, 3, (1897-8): 22-28.

Nuttall, G., *Hygienic Measures in Relation to Infectious Diseases*, (London; G. P. Putmans, 1893).

Ogsten, A., "[Case Of Carbolic Acid Poisoning](#)", *The British Medical Journal*: (Feb. 4, 1871): 116.

Orr, J., *Handbook of Public Health*, (Edinburgh: E & S Livingstone, 1902).

Osborn, S., *Ambulance Lectures on Home Nursing and Hygiene*, (London: H. K. Lewis, 1891).

Page, D., *Facts About Fevers*, (Edinburgh: MacLaughlan and Stewart, 1880).

- Parker, Mr., "Discussion of infectious diseases and disinfection", *Sanitary Journal*, 12, (1906-7): 219-20 .
- Parker, L. C., 'A guide to the use of disinfectants', *Journal of the Sanitary Institute*, (1911): 317-320.
- Parkes, E., A., *A Manual of Practical Hygiene*, (London: J. & A. Churchill, 1864).
- Parkes, E., A., *A Manual of Practical Hygiene*, 2nd Ed., (London: J. & A. Churchill, 1866).
- Parkes, E., A., *A Manual of Practical Hygiene*, 3rd Ed., (London: J. & A. Churchill, 1869).
- Parkes, E., A., *A Manual of Practical Hygiene*, 4th Ed. (London: J. & A. Churchill, 1873).
- Parkes, E., A., *A Manual of Practical Hygiene*, 5th Ed., (London: J. & A. Churchill, 1878).
- Parkes, E., A., *A Manual of Practical Hygiene*, ed. F. de Chaumont, 7th ed, (London: J. & A. Churchill, 1887).
- Parkes, E., A., *A Manual of Practical Hygiene*, ed. F. de Chaumont, 6th ed, (London: J. & A. Churchill, 1883).
- Parkes, E., A., *Manual of Practical Hygiene*, ed. J. Notter, 8th Ed., (London; J. A. Churchill, 1891).
- Parkes, L. C., "The prevention of phthisis", *Public Health*, 5, (1892-3): 308-9.
- Partridge, W., *Bacteriological Examination of Disinfectants*, (London: The Sanitary Publishing Company, 1907).
- Parsons, H. F., P. Caldwell Smith, W. Squire, E. W. Hope, C. H. Allfrey, 'A discussion on disinfection and isolation', *British Medical Journal*, (Aug 31st 1889): 452-9.
- Parsons, H. F., *Isolation Hospitals*, 2nd ed. (Cambridge: Cambridge University Press, 1922).
- Peacock, W., "Disinfection and disinfectants", *Sanitary Journal*, 14, (1908-9): 239-41.
- Penneck, H., "On the nature and treatment of cholera", *The Lancet*, (3rd March 1832): 798-799.
- Phillips, B., *Epidemic Contagion and Infection*, (London: Longman, 1832).
- Pidduck, I., "The cause, prevention and treatment of typhus fever", *The Lancet*, (14th August 1847): 176.
- Pilcher, Mr., 'Medical Society of London', *The Lancet*, (2nd March 1844): 772-5.
- Pilkington, W., *Then and Now*, (Preston: W. Pilkington, 1911).
- Planner, W. M., "Standardisation of disinfectants", *The Lancet*, (Jan. 16th 1909): 193.

Planner, W. M., S. Rideal, 'The standardisation of disinfectants', *The Lancet*, (19th Dec 1908): 1845.

Porter, C., "Library Books and Infectious Disease", *British Medical Journal*, (12th Jan.1895): 110-111.

Porter, H., "Case of poisoning by Sir William Burnett's disinfectant fluid: recovery", *The British Medical Journal*, (Aug. 13th 1859): 651-2.

Poyntz Wright, T., "On the use of the Equifex sprayer", *Public Health*, 9, (1896-7): 63-5.

Ransom, W. H., "Disinfection by heat", *British Medical Journal*, (13th Jun 1874): 788-9.

Ransome, A., "How are we to deal with convalescents from acute infectious diseases?", *British Medical Journal*, (May 8th 1880): 688-90.

Ransome, A., 'An address at the opening of the section on public medicine', *British Medical Journal*, (Aug 27th 1881): 352-55.

Ransome, A., "Epidemiological society: the prospect of banishing pthisis", *Public Health*, 11, (1898-9): 293-8.

Ransome, A., J. Niven, "The prevention of pthisis", *Public Health*, 5, (1892-3): 282-4

Renney, H., "Disinfection of books", *Public Health*, 23, (1909-10): 213-4.

Richmond, L., *Children: A Book for Mothers*, (London: Griffith, Farron, Okden and Welsh, 1890).

Rideal, O., 'Disinfection: a research on the disinfecting and antiseptic properties of trichloride of iodine', *Public Health*, (1888-9): 58-9.

Rideal, S., *Disinfection and the Preservation of Food*, (London: The Sanitary Publishing Company, 1903).

Rideal, S., *Disinfection and the Preservation of Food*, (London: The Sanitary Publishing Company, 1898).

Rideal, S. and J. T. Ainslie Walker, "Standardisation of disinfectants", *Public Health*, 15, (1902-3): 657-665.

Rideal, S. and J. T. Ainslie Walker, 'Control of disinfectants', *The Lancet*, (19th Sept 1908): 902.

Rideal, S. and J. T. Ainslie Walker, "The Rideal Walker Coefficient", *The Lancet*, (April 6th 1907):

- Rideal, S., "Disinfection", *Journal of the Royal Sanitary Institute*, (1907): 374.
- Rideal, S., "Formaldehyde disinfection", *Public Health*, 10, (1897-8): 60-62.
- Rideal, S., "Suggested international test for disinfectants", *The Lancet*, (Sept 13th 1913): 826-7.
- Rideal, S., 'The standardisation of disinfectants', *The Lancet*, (Dec. 18th 1909): 1849-52.
- Rideal, S., 'The comparative germicidal action of some disinfectants', *The Lancet*, (July 28th 1900): 293.
- Rideal, S., "Formaldehyde Disinfection", *Journal of the Sanitary Institute*, (1902): 508.
- Rideal, S., 'Creolin: a note of warning', *Public Health*, 16, (1903-4): 156-160.
- Rideal, S. and J. T. Ainslie Walker, "Standardization of disinfectants", *Journal of the Sanitary Institute*, (1903): 424-441.
- Rideal, S., C. T. Kingzett, 'The standardisation of disinfectants', *The Lancet*, (18th Dec 1909): 1849-52.
- Robertson, W. G., *Manual of Medical Jurisprudence, Toxicology and Public Health*, 2nd Ed., (London: Simpkin, Marshall, 1910).
- Robertson, W. G., *Manual of Medical Jurisprudence, Toxicology and Public Health*, (London: Simpkin, Marshall, 1908).
- Robertson, W., "The merits of pressure and non-pressure steam in disinfection", *Public Health*, 18, (1905-6): 289-96.
- Robertson, W., "The essential conditions of steam disinfection", *The Lancet*, (11th Nov 1905): 1431-2.
- Rogers, L., 'Disinfection of floors for plague', *Journal of Hygiene*, 2, (April 1902): 129-140.
- Roose, R., *Infection and Disinfection*, (London: Chapman and Hall, 1888).
- Rosenau, M., *A Practical Guide to Disinfection*, (London, Robman, 1903).
- Russell, W., *Domestic Medicine and Hygiene*, (London: W. H. Everett, 1878).
- Sandilands, J. E., "The compulsory notification of measles", *Public Health*, 14, (1910-11): 26.
- Sanson, A., *The Antiseptic System*, (London: Henry Gillman, 1871).
- Sanson, A., "Disinfection", *Medical Times and Gazette*, 45, (1872): 332.
- Savill, T. D., *Prescriber's Companion*, (London: Bale, Sons, and Donielson, 1900).
- Scannell, D., *Mother Knew Best: an East End childhood*, (London: Macmillan, 1874).
- Schofield, A., *Manual of Personal and Domestic Hygiene*, (London: 1890).
- Schofield, A. T., *The Home Life in Order*, (London: Hodder and Stoughton, 1906).

Scoles, J. *History of Bolton*, (Bolton: Daily Chronicle Officer, 1892).

Seaton, E., "Infectious diseases and modes of disinfection", *Journal of the Sanitary Institute*, (1895): 452-62.

Simpson, W. J. R. and R. T. Hewlett, 'The Rideal-Walker method of testing disinfectants', *The Lancet*, (Aug. 20th 1904): 524-5.

Simon, J., *English Sanitary Institutions: Reviewed in Their Course of Development, and in Some of Their Political and Social Relations*, (London: Cassel, 1890).

Sims Woodhead, G., *Bacteria and Their Products*, (London: Walter Scott, 1891).

Skinner, T., "Deodorisation in carcinoma uteri", *British Medical Journal*, (3rd Sept. 1859): 979-82.

Smart, A., *Germ, Dust and Disease*, (Edinburgh: MacNiven and Wallace, 1883).

Smith, E., *Manual for Medical Officers of Health*, (London: Knight and Co., 1873).

Smith, E., *Manual for Medical Officers of Health*, 2nd ed. (London: Knight and Co., 1874).

Smith, R. A., *Disinfection and Disinfectants*, (Edinburgh: Edmeston and Douglas, 1869).

Smith, R. S. and C. Praunitz, "The determination of the efficacy of disinfection", *Journal of Preventative Medicine*, 14, (1906): 746-55.

Smyth, J. C., *An Account of Experiments*, (London: J. Johnson, 1796).

Sommerville, D. T. and J. T. Ainslie Walker, "Standardisation of disinfectants", *Public Health*, 18, (1905-6): 526-8.

Sommerville, D. T. and J. T. Ainslie Walker, "On the disinfectant properties of hypochlorites", *The Lancet*, (27th October 1906): 1143-44.

Sommerville, D. T. and J. T. Ainslie Walker, "Hypochlorites produced by electrolysis", *The Lancet*, (17th Nov 1906): 1400.

Spottiswoode Cameron, E., "Disinfection", *Journal of the Sanitary Institute*, (1897): 397-416.

Spottiswoode Cameron, E., "Sanitary progress during the last twenty five years and in the next", *Public Health*, 15, (1902-3): 64-93.

Starr, L., *Hygiene of the Nursery*, (London: H. K. Lewis, 1913).

Stenhouse, J., *The Successful Application of Charcoal Air Filters*, (London: J&A Churchill, 1861).

Stephenson, W., *The Fight with Infection*, (Aberdeen: D. Wyllie and Son, 1879).

Strange, W., *The Seven Sources of Health*, (London: L. Renshaw, 1883).

Sykes, J. F., *Public Health Problems*, (London: Walter Scott, 1892).

Tanner Hewlett, R., “The Milroy Lectures on disinfection and disinfectants”, *The Lancet*, (March 27th 1909): 889-894.

Tanner Hewlett, R., “The Milroy Lectures on Disinfection and Disinfectants”, *The Lancet*, (13th March 1909): 741-745.

Taylor, J., “Arsenic in surgery”, *The Lancet*, (30th July 1864): 124.

Thresh, J. C., “The essential conditions of steam disinfection“, *The Lancet*, (18th Nov 1905): 1506.

Thresh, J. C., “The co-efficient of disinfectants“, *Public Health*, 20, (1907-8): 261.

Thresh, J. C., “The essential conditions of steam disinfection“, *The Lancet*, (7th Oct 1905): 1061.

Thresh J. C. and G. Sowden, “Formaldehyde Disinfection“, *Journal of the Sanitary Institute*, (1902): 515.

Thorne, R. T., *On the Progress of Preventive Medicine During the Victorian Era*, (London: Shaw and Sons, 1888).

Timins, J. H., *On Artificial Disinfectants*, (London: J. & A. Churchill, 1878).

Todd, G., “A series of papers on the causes and nature of continued fever“, *The Lancet*, (24th Feb 1849): 202-4.

Tomkins , H. Y. and E. M. Shirliff, “Notification of Infectious Diseases”, *The Lancet*, (16 June 1888): 1220-1221.

Tripe, Dr., “Carbolic“, *Medical Times and Gazette*, 60, (1880): 51.

Truman, M. and E. Sykes, *Disinfection*, (London: The Roxburgh Press, c.1896).

Tyndall, J., *Essays on the Floating Matter of the Air*, (London: 1881).

Vacher, D. “North Western Branch“, *Sanitary Journal*, 10, (1904-5): 87-92.

Vallin, D. E., “Disinfection by hot air“, *The Practitioner*, 20, (1878): 236.

Vallin, E., “The compulsory notification of measles and infectious pneumonia“, *Public Health*, 4, (12, Aug 1900): 802-4.

Vans Best, A., *Papers of Epidemic Hospitals and Other Subjects*, (Aberdeen: D. Wyllie and Son, 1873).

Various, *First Report of the Commissioners on the State of Large Towns, Vol. I.*, (London: Clowes and Sons, 1844).

Waldo, F. J. “The sanitary supervision of shelters“, *Public Health*, 9, (1896-7): 200-1.

Walker, J. T., ‘The comparative germicidal value of some disinfectants’, *The Lancet*, (21st July 1900): 222;

Walker, J. T., 'The standardisation of disinfectants', *The Lancet*, (Jan 1st 1910): 68-9.

Walker, J. T., "Disinfection", *The Practitioner*, 69, (1902): 521.

Wallace, W. and F. R. Barker, "On the disinfecting powers of heat," *The Lancet*, (17th March 1832): 854-7

Walter Verdon, H., "The degree of temperature necessary to destroy infectious germs", *The Lancet*, (Jan 19th 1884): 139.

Wardell, J. R., "Report on a case of poisoning by Burnett's fluid", *The Lancet*, (9th Jan. 1864): 35-6.

Watson, J., *A Handbook for Nurses*, (London: The Scientific Press, 1899).

Watson, J., *A Handbook for Nurses*, 8th ed, (London: The Scientific Press, 1928).

Weatherly, L. A., *Lectures on Domestic Hygiene*, (London: Griffiths and Fanon, 1880).

Weiss, J. M., "Recent progress in the standardisation of disinfectants", *Journal of the Franklin Institute*, 175, (June 1913): 615-625.

Weymyss Bogg, T., "A case of poisoning by corrosive sublimate", *The Lancet*, (21st December 1878): 876-877.

Wheeler, A., *Our Unseen Foes*, (London: Simpkin, Marshall, Hamilton, Kent & Co., 1891).

White Wallis, I., *Manual of Hygiene*, (London: Keegan Paul, 1894).

Williams, A. W., *Domestic Hygiene*, (London: George Bell & Sons, 1898).

Williams, M., *The Velveteen Rabbit*, (London: Little Mammoth, 1989).

Williams, R., 'Examination of commercial carbolic acid disinfectants', *Journal of the Society Chemical Industry*, (Dec 31st 1888): 826-7.

Willoughby, E. F., *Handbook of Public Health and Demography*, (London: Macmillan and Co., 1893).

Wilson, G., *Handbook of Hygiene*, 2nd Ed., (London: J&A Churchill, 1873).

Wilson, G., *Handbook of Hygiene*, 3rd Ed., (London: J&A Churchill, 1877).

Wilson, G., *Handbook of Hygiene*, 4th Ed., (London: J&A Churchill, 1879).

Wilson, G., *Handbook of Hygiene*, 6th Ed., (London: J&A Churchill, 1886).

Wilson, G., *Handbook of Hygiene*, 7th Ed., (London: J&A Churchill, 1892).

Woodward, K., *Jipping Street*, (London: Harper & Row, 1928).

Wynn Williams, A., "Is iodine a disinfectant?", *The Lancet*, 18 Feb 1882: 290-1.

Wynter Blyth, A., 'Criticisms of the health exhibition disinfectants', *Medical Times and Gazette*, (Oct 11th 1884): 498-500.

Wynter Blyth, A., *Manual of Public Health*, (London: Macmillan and Co., 1890).

Wynter Blyth, A. and M. Wynter Blyth, *Poisons: Their Effects and Detection*, 4th ed. (London: Charles Griffen and Co., 1906).

Wynter Blyth, A., "Experiments as to the disinfecting power of formic aldehyde", *Public Health*, 10, (1897-8): 307-8.

Wynter Blyth, A., 'Criticisms of the health exhibition disinfectants', *Medical Times and Gazette*, (Oct 11th 1884): 498.

Yates, G. H., *New and Complete Domestic Medicine*, (London: 1879).

Youatt, W., "On epizootic diseases", *The Lancet*, (29th Jan 1842): 619-21.

Zimmerman, A., 'Formic aldehyde disinfection', *Public Health*, 10, (1897-8): 175-6.

Unpublished secondary works

Crook, T. "Norms, forms and bodies: public health, liberalism and the Victorian city 1830-1900", (Manchester PhD, 2004).

Sheard, S., "Nineteenth Century Public Health: A Study of Liverpool, Belfast and Glasgow", (University of Liverpool PhD, 1993).

Smith, V., "Cleanliness: the development of idea and practice in Britain, 1770-1850", (London: LSE PhD Thesis, 1985).

Watkins, D., "The English Revolution in Social Medicine", (University College London: PhD Thesis, 1984).

Wilkinson, A., "The beginnings of disease control in London", (University of Oxford: DPhil, 1980).

Young, R. K., "Sanitary administration under the Local Government Board, 1871-1888", (Oxford: Blitt, 1964).

Secondary Literature

Ackerknecht, E. H., "Anticontagionism between 1821 and 1867", *Bulletin of the History of Medicine*, 22, (1948): 562-93.

Anderson, O., *Suicide in Victorian and Edwardian England*, (Oxford: Clarendon Press, 1987).

Atkins, P. J., "Adulteration of the milk supply", *Social History*, 16, (Aug. 1991): 317-339.

- Ayliffe, G. and M. English, *Hospital Infection: from Miasmas to MRSA*, (Cambridge: Cambridge University Press, 2003).
- Bailey, V., *This Rash Act: Suicide across the Lifecycle in the Victorian City*, (Stanford, C.A.,: Stanford University Press, 1998).
- Baldwin, P. *Contagion and the State in Europe 1830-1930*, (Cambridge: Cambridge University Press, 1999).
- Barker, T. C. and J. R. Harris, *A Merseyside Town in the Industrial Revolution*, (Frank Cass, London, 1993).
- Bartrip, P., *Themselves Writ Large: The British Medical Association 1832-1966*, (London: British Medical Journal, 1996).
- Bartrip, P., *Mirror of Medicine: A History of the British Medical Journal*, (Oxford: Clarendon Press, 1990).
- Bartrip, P., "A 'Pennurth of arsenic for rat poison': The Arsenic Act, 1851, and the prevention of secret poisoning", *Medical History*, 36, (1992): 53-69.
- Bartrip, P., 'British government inspection, 1832-1975: some observations', *The Historical Journal*, 25, (1982): 605-26.
- Beier, L., *For Their Own Good: the Transformation of English Working-Class Health Culture, 1880-1970*, (Colombus: Ohio State Press, 2008).
- Bell, F. and R. Milward, "Public health expenditure and mortality in England and Wales, 1870-1914", *Continuity and Change*, 13, (April 1998): 221-50.
- Bellamy, C., *Administering Central Local Relations, 1871-1919*, (Manchester: Manchester University Press, 1998).
- Berridge, V., *Opium and the People: Opiate Use and Drug Control Policy*, (London: Free Association Press, 1981).
- Bickerton, T. H., *A Medical History of Liverpool*, (London: John Murray, 1936).
- Brock, W. H., *Justus von Liebig: The Chemical Gatekeeper*, (Cambridge: Cambridge University Press, 1997).
- Brunton, D., "Policy, powers and practice: the public response to the public health in the Scottish city", in *Medicine, Health and the Public Sphere in Britain, 1600-2000*, ed. S. Sturdy (London: Routledge, 2002), 171-188.
- Bryder, L., *Below the Magic Mountain: A Social History of Tuberculosis in Twentieth Century Britain*, (Oxford: Clarendon, 1988).
- Buckmaster, J. C., *The Elements of Inorganic Chemistry*, (London: Longman, Brown, Green,

- Longmans, & Roberts, 1858).
- Burney, I., *Poison, Detection and the Victorian Imagination*, (Manchester: Manchester University Press, 2006).
- Bynum, W. F., *Science and the Practice of Medicine in the Nineteenth Century*, (Cambridge: Cambridge University Press, 1994).
- Bynum, W. F., "Darwin and the doctors: evolution, diathesis and germs in nineteenth century Britain", *Gesnerus*, 40, (1983), 43-53.
- Campkin, B. and R. Cox (eds.), *Dirt: New Geographies of Cleanliness and Contamination*, (London: I. B. Tauris, 2007).
- Cassidy, J. H., *Charles Chapin and the Public Health Movement*, (Cambridge, Mass.: Harvard University Press, 1962).
- Chase, K. and M. Levenson, *The Spectre of Intimacy: A Public Life for the Victorian Family*, (Princeton: Princeton University Press, 2000).
- Cherry, S., *Medical Services and the Hospitals*, (Cambridge: Cambridge University Press, 1996).
- Crook, T., 'Sanitary inspection and the public sphere in late Victorian and Edwardian England: a study in liberal governance' *Social History*, 32 (November 2007): 369-93.
- Crowther, M. A. and M. W. Dupree, *Medical Lives in the Age of Surgical Revolution*, (Cambridge: Cambridge University Press, 2007).
- Crowther, M. A., *The Workhouse System*, (London: Batsford, 1981).
- Cunnigham, A., "Transforming plague: the laboratory and the identity of infectious disease", in *The Laboratory Revolution in Medicine*, ed. A. Cunnigham and P. Williams, (Cambridge: Cambridge University Press, 1992), 209-244.
- Cunnigham, A. and P. Williams, "Introduction", in *The Laboratory Revolution in Medicine*, ed. A. Cunnigham and P. Williams, (Cambridge: Cambridge University Press, 1992), 1-13.
- Currie, M., *Fever Hospitals and Fever Nurses: a British Social History of Fever Nursing: a National Service*, (London: Routledge, 2005).
- Daunton, M., "Public place and private space: the Victorian city and the working class household", in *The Pursuit of Urban History*, ed. D. Fraser and A. Sutcliffe. (London: Edward Arnold, 1993), 212-233.
- Daunton, M., *House and Home in the Victorian City*, (London: Edward Arnold, 1983).
- Daunton, M., *Trusting Leviathan: the Politics of Taxation in Britain, 1799-1914*, (Cambridge:

- Cambridge University Press, 2001).
- Dacey, A. V., *The Privy Council*, (London: Macmillan, 1887).
- Digby, A., *The Evolution of British General Practice, 1850-1948*, (Oxford: Oxford University Press, 1999);
- Dobson, B., *A Preston Mixture*, (Blackpool: Londy Publishing, 2003).
- Douglas, M., *Purity and Danger: an Analysis of Concepts of Pollution and Taboo*, (London: Routledge, 1966).
- Dunsheath, P. (ed.), *A Century of Technology, 1851-1951*, (London, Hutchinsons, 1951). .
- Durbach, N., *Bodily Matters: the Anti-Vaccination Movement in England, 1853-1907* (London: Duke University Press, 2005).
- Dwork, D., "The milk option: an aspect of the infant welfare movement in England, 1898-1908", *Medical History*, 31, (Jan. 1987): 51-69.
- Dyehouse, C., "Working class mothers and infant mortality in England, 1895-1914", *Journal of Social History*, 12, (Winter 1978): 248-267.
- Eyler, J. M., *Victorian Social Medicine: the Ideas and Methods of William Farr*, (London: Johns Hopkins University Press, 1979).
- Eyler, J. M., *Sir Arthur Newsholme and State Medicine, 1885-1935*, (Cambridge: Cambridge University Press, 1997).
- Fildes, V., 'Infant feeding practices and infant mortality' *Continuity and Change* 13 (March 1998): 251-280.
- Farrar, W. V., *Chemistry and the Chemical Industry in the Nineteenth Century*, ed. R. Hills and W. H. Brock, (Aldershot: Variorum, 1997).
- Fitzroy, A., *The History of the Privy Council*, (London: J. Murray, 1928).
- Flinn, M., (ed.) *E. Chadwick Report on the Sanitary Condition of the Laboring Population of Great Britain* (Edinburgh, Edinburgh University Press 1965).
- Forman, C., *Industrial Town: Self Portrait of St. Helens in the 1920s*, (St. Helens: Cameron and Tayleur, 1978).
- Frazer, W. M., *A History of English Public Health, 1834-1939*, (London: Balliere, Tindall and Cox, 1950).
- Fruton, J. S., "Biological and clinical chemistry: a retrospect" in *History of Clinical Chemistry*, ed.

- J. Buttner, (Berlin: Walter de Gruyter, 1983), 25-34.
- Garrett, E., C. Galley, N. Shelton and R. Woods, "Infant mortality: a social problem?", in E. Garrett, C. Galley, N. Shelton and R. Woods, *Infant Mortality: A Continuing Social Problem*, (Aldershot: Ashgate, 2006), 3-16.
- Haber, L. F., *The Chemical Industry During the Nineteenth Century*, (Oxford: Clarendon Press, 1958).
- Halliday, S., *The Great Filth*, (Stroud: Sutton Publishing, 2007).
- Hamlin, C., "Providence and putrefaction: Victorian sanitarians and the natural theology of health and disease", *Victorian Studies*, 28, 3, (1985), 381-411.
- Hamlin, C., *A Science of Impurity: Water Analysis in Nineteenth Century Britain*, (Bristol: Hilger, 1990).
- Hamlin, C., "Muddling in Bumbledom: On the Enormity of Large Sanitary Improvements in Four British Towns, 1855-1885", *Victorian Studies*, 32, (Autumn 1998): 55-83.
- Hamlin, C., *Public Health and Social Justice in the Age of Chadwick: Britain, 1800-1854*, (Cambridge: Cambridge University Press, 1998).
- Hamlin, C., 'Sanitary policing and the local state 1873-1874: a statistical study of English and Welsh towns' *Social History of Medicine*, 18 (January 2005): 39-61.
- Hamlin, C., 'Politics and germ theory', in *Government and Expertise: Specialists, Administrators and Professionals*, ed. R. MacLeod, (Cambridge: Cambridge University Press, 1988), 110-127.
- Hamlin, C., "The transformation of "nuisance", in *Medicine, Health and the Public Sphere in Britain, 1600-2000*, ed. S. Sturdy (London: Routledge, 2002), 189-204.
- Hamlin, C., 'Edwin Chadwick, 'mutton medicine,' and the fever question'. *Bulletin of the History of Medicine*, 70:2 (1996), 233-265.
- Hamlin, C. *Cholera: The Biography*, (Oxford: Oxford University Press, 2009).
- Hamlin, C., *Public Health and Social Justice in the Age of Chadwick, Britain 1800-1854*, (Cambridge: Cambridge University Press, 1998).
- Hanley, J., "Parliament, physicians and nuisances: the demedicalisation of nuisance law, 1831-1855", *Bulletin of the History of Medicine*, 80, (2006), 702-732 .
- Hardy, A., "Lyon Playfair and the idea of progress: science and medicine in Victorian Parliament", in *Doctors, Politics and Society; Historical Essays*, ed. D. Porter and R. Porter, (Amsterdam: Rodopi, 1993), 81-106.
- Hardy, A., "Cholera, quarantine and the English preventive system, 1850-1895", *Medical History*,

37, (1993): 250-269.

Hardy, A., *The Epidemic Streets*, (Oxford: Clarendon Press, 1993).

Hardy, A. "Public Health and the expert; the London medical officers of health, 1856-1900", in *Government and Expertise*, ed. R. Macleod, (Cambridge: Cambridge University Press, 1988), 128-144.

Hardy, A., 'Smallpox in London: factors in the decline of the disease in the nineteenth century', *Medical History*, 27 (April 1983): 111-138.

Hardy, A., "Lyon Playfair and the idea of progress: science and medicine in Victorian Parliament", in *Doctors, Politics and Society; Historical Essays*, ed. D. Porter and R. Porter, (Amsterdam: Rodopi, 1993), 81-106.

Hardy, A., *Health and Medicine in Britain Since 1860*, (Basingstoke: Palgrave, 2001).

Hardy, A., "Urban famine or urban crisis? Typhus in the Victorian City", *Medical History*, 32, (1988): 401-425.

Harris Library, *A Tour of Edwardian Preston*, (Preston: Harris Library, 1996).

Hennock, E. P., "Vaccination Policy Against Smallpox, 1835-1914: A Comparison of England with

Prussia and Imperial Germany", *Social History of Medicine*, 11, (1998): 49-71.

Hennock, E. P., *Fit and Proper Persons: Ideal and Reality in Nineteenth-Century Urban Government* (London: Edward Arnold, 1973).

Hewitson, A., *History of Preston 1883*, (Preston: S. R. Publishers, 1969).

Holloway, S., "The regulation of the sale of drugs in Britain before 1868", in R. Porter and M. Teich, *Drugs and Narcotics in History*, (Cambridge: Cambridge University Press, 1995), 77-96.

Holloway, S. *Royal Pharmaceutical Society of Great Britain, 1841-1991*, (London: The Pharmaceutical Press, 1991).

Holmyard, E. J., *Makers of Chemistry*, (Oxford: Oxford University Press, 1931).

Honigsbaum, M., "The Great Dread: Cultural and Psychological Impacts and Responses to the 'Russian' Influenza in the United Kingdom, 1889-1893", *Social History of Medicine*, 23, (2010): 299-319.

Hopkins, E., *A Social History of the English Working Class*, (London: Edward Arnold, 1979).

Horn, P., *The Victorian and Edwardian Schoolchild*, (Gloucester: Alan Sutton Publishers, 1989).

Hoy, S., *Chasing Dirt: the American Pursuit of Cleanliness*, (Oxford: Oxford University Press, 1995).

Hugo, W. B., "A brief history of heat and chemical preservation and disinfection", *Journal of*

- Applied Bacteriology*, 71, (1991): 9-18.
- Hunt, T., *Building Jerusalem*, (London: Weidenfeld and Nicholson, 2004).
- Hunt, D., *A History of Preston*, (Preston: Carnegie and Preston Borough, 1992).
- Jones, J., and M. Jones, *A Most Enterprising Thing*, (Chapeltown: Chapeltown and High Green Archive, 1993).
- Kearns, G., P. Laxton and J. Campbell, "Duncan and the Cholera Test", *Transactions of the Historical Society of Lancashire and Cheshire*, 143, (1993): 87-116.
- Kearns, G., 'Cholera, nuisances and environmental management in Islington, 1830-1855' in *Living and Dying in London*, ed. W. F. Bynum and R. Porter, (London: Wellcome Institute, 1991), 94-125.
- Kelley, V., 'The Virtues of a Drop of Cleansing Water': domestic work and cleanliness in the British working classes, 1880-1914', *Women's History Review*, 18 (2009): 619-637.
- Kelley, V., *Soap and Water: Cleanliness, Dirt and the Working Classes in Victorian and Edwardian Britain*, (London: I. B. Tauris, 2010).
- Kidd, A. J., *Manchester*, 3rd ed., (Edinburgh: Edinburgh University Press, 2002).
- Kidd, A. J., "Introduction: the middle class in nineteenth century Manchester", in *City, Class and Culture: Studies of Social Policy and Cultural Production in Victorian Manchester*, (Manchester: Manchester University Press, 1985), 1-25.
- Lancashire Federation of Women's Institutes, *Lancashire Within Living Memory*, (Newbury: Countryside Books, 1997).
- Lees, L. H., "Urban networks", in *The Cambridge Urban History*, Vol. III, ed. M. Daunton, (Cambridge: Cambridge University Press), 50-94.
- Lloyd, C., and J. L. S. Coulter, *Medicine and the Navy, Vol. 4 1815-1900*, (London: E.&S. Livingstone Ltd., 1963).
- Loeb, L., "Beating the 'flu: orthodox and commercial responses to influenza in Britain, 1889-1919", *Social History of Medicine*, 18 (Spring 2005): 203-224.
- Loeb, L., *Consuming Angels: Advertising and Victorian Women*, (Oxford: Oxford University Press, 1993).
- McGrew, R. E., *Encyclopaedia of Medical History*, London: Macmillan, 1985).
- Macleod, R., "The Alkali Acts administration, 1863-84 : the emergence of the civil scientist", *Victorian Studies*, 9, (Spring 1965): 85-112.

- Macleod, R., "Government and Resource Conservation: the Salmon Acts Administration, 1860-86", *Journal of British Studies*, 7, (Spring 1968): 114-150.
- Macleod, R., "Introduction", in *Government and Expertise*, ed. R. Macleod, (Cambridge: Cambridge University Press, 2003), 1-19.
- Malone, C., *Women's Bodies and Dangerous Trades in England, 1880-1914*, (Woodbridge: The Boydell Press, 2003).
- Marland, H., "A pioneer in infant welfare: the Huddersfield scheme, 1903-1920", *Social History of Medicine*, 6, (April 1993): 25-50.
- McKeown, T., *The Modern Rise of Population* (London: Arnold, 1976).
- Milward, R. and S. Sheard, "The urban fiscal problem 1870-1914", *Economic History Review*, 48, (Aug. 1995): 501-535.
- Mooney, G., 'Public health versus private practice: the contested development of compulsory infectious disease notification in late-nineteenth century Britain', *Bulletin of the History of Medicine*, 73 (March 1999): 238-267.
- Mooney, G., "Infection and citizenship: (not) visiting isolation hospitals in mid-Victorian Britain",
in *Permeable Walls: Historical Perspectives on Hospital and Asylum Visiting*, ed. G. Mooney and J. Reinartz, (New York: Rodopi, 2009), 147-173.
- Morgan, N., "Infant mortality, flies and horses in later nineteenth century towns: a case study of Preston", *Continuity and Change*, 17, (2002): 97-132.
- Morris, P. J., W. A. Campbell and H. L. Roberts, (eds.), *Milestones in One Hundred and Fifty Years of the Chemical Industry*, (Cambridge: Royal Society of Chemistry, 1991).
- Morris, R. J., *Cholera 1832: the Social Response to an Epidemic*, (London: Croom Helm, 1976).
- Nye, M. J., (ed.), *The Modern Physical and Mathematical Sciences*, (Cambridge: Cambridge University Press, 2003).
- Partington, J. R., *A History of Chemistry Volume Four*, (London: Macmillan, 1964).
- Palfreyman, D., *John Jeyes: the Making of a Household Name*, (Thetford: Jeyes Group Ltd, 1977).
- Pelling, M., *Cholera, Fever and English Medicine*, (Oxford: Oxford University Press, 1978).
- Perkin, H., *The Rise of Professional Society*, (London: Routledge, 1989).
- Pickstone, J., *Medicine and Industrial Society: a History of Hospital Development in Manchester and its Region, 1752-1946*, (Manchester: Manchester University Press, 1985).
- Platt, H., *Shock Cities: the Environmental Transformation of Manchester and Chicago*, (London:

- The Chicago University Press, 2005).
- Pooley, M. E. and C. G. Pooley, "Health, society and environment in Victorian Manchester", in *Urban Disease and Mortality in the Nineteenth Century*, ed. R. Woods and J. Woodward, (London: Batsford, 1984), 148-175.
- Porter, R. and D. Porter, (eds.), *Doctors, Politics and Society: Historical Essays*, (Amsterdam: Rodopi, 1993).
- Raymond, J., "Science in the service of medicine", *Bulletin, The Society for the Social History of Medicine*, 37, (1985), 44-5.
- Richards, S., "Anaesthetics, ethics and aesthetics: vivisection in the late nineteenth century British laboratory", in *The Laboratory Revolution in Medicine*, ed. A. Cunnigham and P. Williams, (Cambridge: Cambridge University Press, 1992), 142-169.
- Robertson, S., "The terrible scourge of consumption", in *Social Conditions, Status and Community*, ed. K. Laybourn, (Thrupp: Sutton Publishing, 1997), 45-65.
- Romano, T. M., *Making Medicine Scientific: John Burden Sanderson and the Culture of Victorian Science*, (Baltimore: Johns Hopkins University Press, 2002).
- Rose, J., "Education, literacy and the reader", in *A Companion to the Victorian Novel*, ed. P. Brantlinger and W. B. Thesing, (Oxford: Blackwell, 2002), 31-48.
- Rosen, G., *A History of Public Health*, (London: Johns Hopkins Press, 1958).
- Rosenberg, C. E., *The Care of Strangers*, (Baltimore, MD: Johns Hopkins University Press, 1987).
- Russell, C. A., (ed.), *Chemistry, Society and Environment*, (Cambridge: Royal Society of Chemistry, 2000).
- Savage, M., *The Dynamics of Working Class Politics: The Labour Movement in Preston, 1880-1940*, (Cambridge: Cambridge University Press, 1987).
- Schutt, Hans-Werner, "Chemical atomism and chemical classification", in *The Cambridge History of Science, Volume 5: The Modern Physical and Mathematical Sciences* ed. M. J. Nye, (Cambridge: Cambridge University Press, 2003), 23-255.
- Shapely, P. *Charity and Power in Victorian Manchester*, (Manchester: Smith Settle, 2000).
- Sheard, S., "Water and Health", *Transactions of the Historical Society of Lancashire and Cheshire*, 143, (1993): 141-164.
- Sheard, S., "Profit is a dirty word: the development of public baths and wash houses in Britain,

- 1847-1914", *Social History of Medicine*, 13, (2000), 63-86.
- Sheard, S. and H. Power (eds.), *Body and City: Histories of Urban Public Health*, (Aldershot: Ashgate, 2000).
- Shlomowitz, R., "Introduction", in *Mortality and Migration in the Modern World*, ed. R. Shlomowitz, (Aldershot: Variorum, 1996), 1-16.
- Sidgwick, N., *Chemical Elements and Their Compounds*, (Oxford: Clarendon Press, 1950).
- Sigsworth, M. and M. Worboys, "The public's view of public health in mid-Victorian Britain", *Urban History*, 21, (Feb. 1993), 237-250.
- Simon, J., "Emil Behring's medical culture: from disinfection to serotherapy", *Medical History*, 51, (April 2007): 201-218.
- Smith, F. B., *The People's Health*, (London: Croom Helm, 1979).
- Smith, F. B., *The Retreat of Tuberculosis, 1850-1950*, (London: Croom Helm, 1987).
- Smith, V., *Clean: a History of Personal Hygiene and Purity* (Oxford: Oxford University Press, 2007).
- Szreter, S. *Health and wealth: studies in history and policy* (Rochester, N.Y.: Rochester University Press, 2005).
- Szreter, S., 'The importance of social interventions in Britain's mortality decline c.1850-1914', *Social Science Medicine*, 1, (1988): 1-37.
- Szreter, S., *Fertility, Class and Gender in Britain, 1860-1940*, (Cambridge: Cambridge University Press, 1996).
- Taton, R., (ed.), *Science in the Nineteenth Century*, (London: Thomas and Hudson, 1961).
- Thorsheim, P., *Inventing Pollution: Coal, Smoke and Culture in Britain since 1800*, (Athens, Ohio: Ohio University Press, 2006).
- Timbrell, J., *The Poison Paradox: Chemicals as Friends and Foes*, (Oxford: Oxford University Press, 2005).
- Tomes, N., *The Gospel of Germs*, (Cambridge, Mass.: Harvard University Press, 1998).
- Tomkins, S. M., "The failure of expertise: public health policy in Britain during the 1918-1919 influenza epidemic", *Social History of Medicine*, 5, (Dec. 1992), 435-54.
- Trentmann, F. and V. Taylor, "From users to consumers: water politics in nineteenth century London", in F. Trentmann, (ed.), *The Making of the Consumer: Knowledge, Power and Identity in the Modern World*, (Oxford: Berg, 2006), 53-79.
- Vigarelo, G., *Concepts of Cleanliness: changing attitudes in France since the Middle Ages*, tr. J.

- Birrell, (Cambridge: Cambridge University Press, 1988).
- Vincent, D., *Literacy and Popular Culture: England 1750-1914*, (Cambridge; Cambridge University Press, 1989).
- Waddington, K. *Medical Education at St. Bartholomew's Hospital, 1123-1995*, (Woodbridge: Boydell, 2003).
- Waller, P. J., *Democracy and Sectarianism*, (Liverpool University Press, 1981).
- Weindling, P., "Scientific elites and laboratory organisation in fin de siecle Paris and Berlin", in *The Laboratory Revolution in Medicine*, ed. A. Cunnigham and P. Williams, (Cambridge: Cambridge University Press, 1992), 170-188.
- Weindling, P., "From medical research to clinical practice: serum therapy for diphtheria in the 1890s" in *Medical Innovations in Historical Perspective*, ed. J. Pickstone, (Manchester: Houndsmill, 1992), 72-83.
- Whorton, J. *The Arsenic Century: How Victorian Britain was Poisoned at Home, Work and Play*, (Oxford: Oxford University Press, 2010).
- Wohl, A., *Endangered Lives: Public Health in Victorian Britain*, (London: Dent, 1983).
- Wohl, A., *The Eternal Slum: Housing and Social Policy in Victorian London*, (London: Edward Arnold, 1977).
- Woods, R. *The Demography of Victorian England and Wales*, (Cambridge: Cambridge University Press, 2000).
- Worboys, M., *Spreading Germs*, (Cambridge: Cambridge University Press, 2000).
- Worboys, M., 'Was there a Bacteriological Revolution in late nineteenth-century medicine?', *Studies in the History of Philosophical, Biological & Biomedical Science*, 38 (2007), 20-42. Online Sources
- 1841 Census of England and Wales,
[http://www.histpop.org/ohpr/servlet/PageBrowser?path=Browse/Census \(by date\)&active=yes&mno=17&tocstate=expandnew&display=sections&display=tables&display=pagetitles&pageseq=183&zoom=4](http://www.histpop.org/ohpr/servlet/PageBrowser?path=Browse/Census%20(browse)&active=yes&mno=17&tocstate=expandnew&display=sections&display=tables&display=pagetitles&pageseq=183&zoom=4), (Accessed 11th Jan 2012).
- 1911 Census of England and Wales,
[http://histpop.org/ohpr/servlet/PageBrowser?path=Browse/Census \(by date\)&active=yes&mno=141&tocstate=expandnew&display=sections&display=tables&display=pagetitles&pageseq=41](http://histpop.org/ohpr/servlet/PageBrowser?path=Browse/Census%20(browse)&active=yes&mno=141&tocstate=expandnew&display=sections&display=tables&display=pagetitles&pageseq=41), (Accessed 11th Jan. 2012).

Anonymous, *T. Alcock*, Dictionary of National Biography,

<http://www.oxforddnb.com/view/article/297?docPos=3>, (Accessed 6th Dec. 2011).

Anonymous, *Biography of S. Rideal*,

<http://www.chem.ucl.ac.uk/resources/history/people/rideal.html> (Accessed 31st December 2010)

Anonymous, *Biography of Alexander Wynter Blyth*,

<http://glascoed.com/html/alexanderwynterblyth.html> (Accessed 17th Sept. 2011).

Beetham, M., *Isabella Beeton*, Dictionary of National Biography,

<http://www.oxforddnb.com/view/article/37172?docPos=1>, (Accessed 16th Dec. 2011).

Bettany, G. T., C. E. J. Harrick, *Sir. W. Burnett*, Dictionary of National Biography,

<http://www.oxforddnb.com/view/article/4077?docPos=17>, (Accessed 17th Dec. 2011).

Brock, W. H., *J. Tyndall*, Dictionary of National Biography,

<http://www.oxforddnb.com/view/article/27948?docPos=2>, (Accessed 18th Dec. 2011).

CDC, *Biography of M. Rosenau*,

<http://www.cdc.gov/mmwr/preview/mmwrhtml/mm4840b1.htm>, (Accessed 16th Dec. 2011).

Chick, H., *Prof. C. J. Martin*, Dictionary of National Biography,

<http://www.oxforddnb.com/view/article/34903?docPos=1>, (Accessed 16th Dec. 2011).

Chloride of Lime Safety Card, <http://www.sciencelab.com/msds.php?msdsId=9927478>,

(Accessed 19th Aug. 2010).

Chlorine Gas Safety Card, <http://www.webelements.com/chlorine/>, (Accessed 19th November 2011).

Davidson, D., “Dettol ‘toilet seat’ campaign branded hyperbole”,

<http://www.brandrepublic.com/news/754262/Dettol-toilet-seat-campaign-branded-hyperbole/>, (Accessed 14th Jan. 2012).

Dictionary of National Biography, various entries, <http://www.oxforddnb.com>, (Accessed 29th November 2011).

Drain Cleaner Safety Instructions, Medline Plus, *Drain Cleaner Poisoning*,

<http://www.nlm.nih.gov/medlineplus/ency/article/002779.htm>, (Accessed 15th Dec. 2011).

Eyler, J. M., *A. Newsholme*, Dictionary of National Biography,

<http://www.oxforddnb.com/view/article/35220>, (Accessed 18th Dec. 2011).

Farrer, W. and J. Brownbill (eds.), *Victoria County History, Lancashire*,

<http://www.british-history.ac.uk/report.aspx?compid=41371>, (Accessed 21st Dec. 2011).

Geary, L. M., *Sir Charles Alexander Cameron*, Dictionary of National Biography,

<http://www.oxforddnb.com/view/article/45885?docPos=3>, (Accessed 19th Sept. 2011).

Goldberg, L. "A History of pest control measures in the anthropology collections" , #

<http://cool.conservation-us.org/coolaic/jaic/articles/jaic35-01-003.html> (Accessed 18th December 2010).

Gay, Oonagh, and Anwen Rees, *The Privy Council*,

<http://www.parliament.uk/documents/commons/lib/research/briefings/snpc-3708.pdf>,
(Accessed 13th Dec. 2011).

Greenaway, F., *William Henry*, Dictionary of National Biography,

<http://www.oxforddnb.com/view/article/12981?docPos=4>, (Accessed 16th Dec. 2011).

Hamlin, C., *Robert Angus Smith*, Dictionary of National Biography,

<http://www.oxforddnb.com/view/article/25893>, (Accessed 19th September 2011).

Hamlin, C., *J. Simon*, Dictionary of National Biography,

<http://www.oxforddnb.com/view/article/36097?docPos=2>, (Accessed 18th Dec. 2011).

Harrick, Claire E. J., "W. Watson Cheyne", Dictionary of National Biography,

<http://www.oxforddnb.com/view/article/32396?docPos=11>, (Accessed 6th Dec. 2011).

Harrison, M., *E. Parkes*, Dictionary of National Biography,

<http://www.oxforddnb.com/view/article/21352?docPos=6>, (Accessed 18th Dec. 2011).

John Johnson Collection Online,

http://gateway.proquest.com/openurl?url_ver=Z39.88-2004&res_dat=xri:jjohnson:&rft_dat=xri:jjohnson:rec:200709190913571b (Accessed 23rd August 2011).

Levitt, I., *W. Leslie Mackenzie*, Dictionary of National Biography,

<http://www.oxforddnb.com/view/article/55652?docPos=2>, (Accessed 6th Dec. 2011).

Mercury Chloride Safety Card, <http://www.inchem.org/documents/icsc/icsc/eics0979.htm>,
(Accessed 18th Dec 2010).

Nitric Acid Safety Card, http://msds.chem.ox.ac.uk/NI/nitric_acid.html, (Accessed 29th July 2011).

Pelling, M., *William Budd*, Dictionary of National Biography,
(<http://www.oxforddnb.com/view/article/3881>), (Accessed 19th September 2011).

Power, D. A., P. Wallis, *R. Thorne Thorne*,
<http://www.oxforddnb.com/view/article/27346?docPos=11>, (Accessed 29th July 2011).

Prosser, R. B. and R. C. Cox, *J. H. Kyan*, Dictionary of National Biography,
<http://www.oxforddnb.com/view/article/15813>, (Accessed 18th Dec 2010)

Rae, I. D., *H. Bollman Condry*, Dictionary of National Biography,
(<http://www.oxforddnb.com/view/article/37307>), (Accessed 19th September 2011).

Sinclair, H. M. ed. D. Smith, *Harriette Chick*, Dictionary of National Biography,
<http://www.oxforddnb.com/view/article/30924>, (Accessed 16th Dec. 2011).

Sturdy, S., *Sir George Newman*, Dictionary of National Biography,
(<http://www.oxforddnb.com/view/article/35215>), (Accessed 19th September 2011).

Worboys, M., *L. Beale*, Dictionary of National Biography,
<http://www.oxforddnb.com/view/article/30656>, (Accessed 16th Dec. 2011).

Worboys, M., *Sheridan Delepine*, Dictionary of National Biography,
<http://www.oxforddnb.com/view/article/57113>, (Accessed 6th Dec. 2011).

Worboys, M., *E. E. Klein*, Dictionary of National Biography,
<http://www.oxforddnb.com/view/article/57359>, (Accessed 18th Dec. 2011).